HIGH-END COMPUTING CAPABILITY PORTFOLIO

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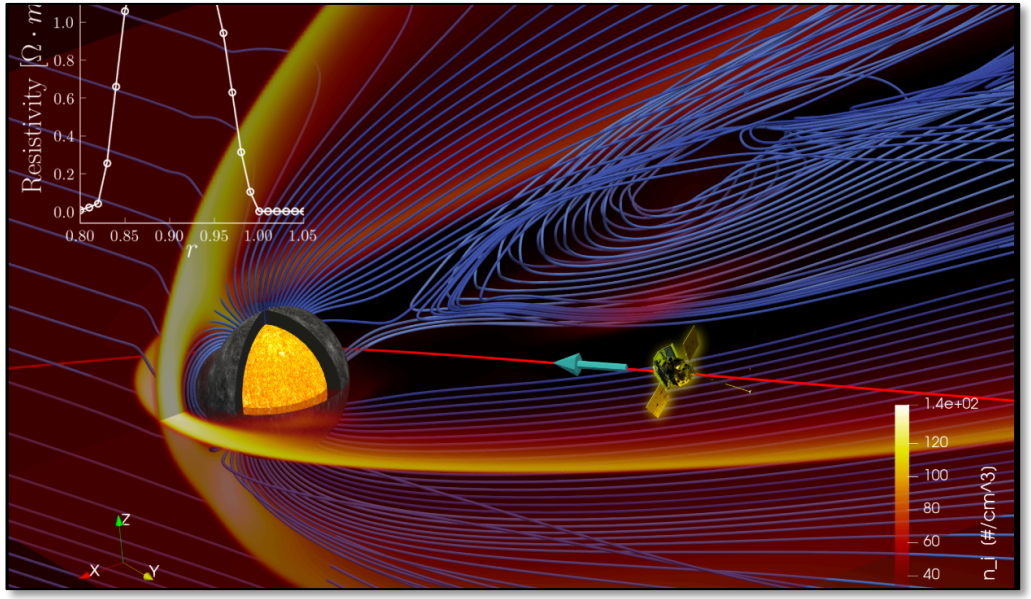
January 10, 2020

HECC Supercomputer Usage Sets New Record in December 2019

- In December, the combined usage of HECC supercomputers set a new record of 9,338,644 Standard Billing Units (SBUs).*
- The usage by 346 of NASA's science and engineering groups exceeded the previous record of 9,258,504 SBUs set in October 2019 by 80,140 SBUs.
- The record was achieved in great part by the Science Mission Directorate's Heliophysics group for their Integration of Extended MHD and Kinetic Effects in Global Magnetosphere Models project.
- Usage of Pleaides, Electra, Aitken, Merope, and Endeavour contributed to this record.
- The top 10 projects' usage ranged between 198,304 and 1,173,606 SBUs, and together accounted for over 39% of the total usage.
- The HECC Project is evaluating options for the next expansion of the Aitken system to better address current requirements.

IMPACT: The increased capacity of HECC systems and working with users to optimize their run capacities provides mission directorates with more resources to accomplish their requirements and goals.



The top project in December 2019—a study of the solar wind interaction with Mercury, Earth, and Uranus—used over one million SBUs. This image shows Mercury's 3D magnetosphere from a novel ten-moment multifluid simulation. The red line together with a cyan arrow represents the trajectory of the MESSENGER spacecraft.

** 1 SBU represents the work that can be done in 1 hour on a Pleiades Broadwell 28-core node.*

HECC Deploys New Lustre Quality of Service Functionality

- Systems experts recently deployed Quality of Service (QoS) on the HECC Lustre filesystems to improve the overall responsiveness for users.
- Lustre QoS minimizes the impact of applications with suboptimal filesystem access patterns by limiting those applications to a maximum number of Input/Output Operations Per Second (IOPS). As a result, applications with optimal Lustre filesystem access patterns are not impacted and provide an overall better experience for most users.
- This also has a side effect of encouraging users with suboptimal filesystem access patterns to focus development efforts on their application's I/O; as well as to report issues through support tickets to HECC—giving HECC staff an opportunity to assist users with improving their I/O to perform better on the Lustre filesystems.
- Support staff observed improved interactive performance on the filesystems, as measured by automated performance tests since the implementation of QoS.

IMPACT: Implementation of Lustre Quality of Service provides a better overall user experience and enables more efficient usage of HECC resources.

HECC's high-performance, shared Lustre filesystem is highly scalable and can support many thousands of client nodes, petabytes of storage, and hundreds of gigabytes per second of I/O throughput.

First High-Resolution Visualizations Created from Coupled GEOS5–MITgcm Simulation Output

- The HECC Visualization and Data Analysis team created several high-resolution visualizations of the recent coupled GEOS5-MITgcm simulation so that domain scientists can review the results and understand the simulation coupling.
  - The team created over 35 animations in 6K and 4K resolution that show the entire domain in high detail.
  - The animations were created using both a latitude-longitude projection and a polar projection and showed 11 different scalar fields; the derivatives of some slowly changing fields were also shown.
- Two domain scientists visited the NAS facility on December 13, and spent the entire day using an interactive hyperwall application to explore the data.
  - Nearly all the 2D and 3D scalar fields of the MITgcm ocean data were converted to the application's format and were available to view.
  - Over 100 2D fields of the GEOS5 atmospheric data were also converted and viewable.
  - 800+ different animation layouts were available allowing the scientists to investigate different scenarios.
- The Visualization team is creating more animations based on scientists' feedback and preparing for a return visit in March 2020.

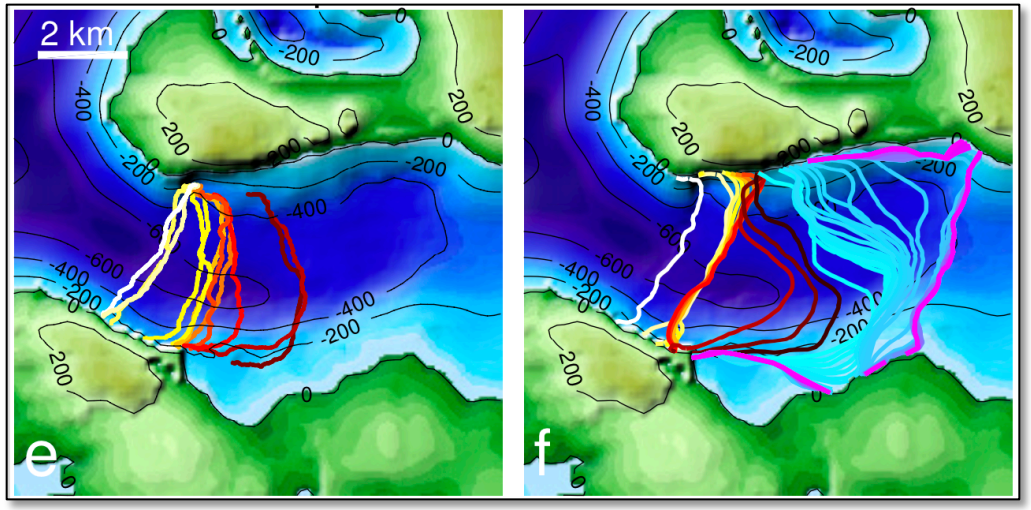
IMPACT: HECC-developed interactive exploration tools and visualization expertise enabled domain scientists to find several possibly anomalous features in their Earth science data that need further investigation.

Dimitris Menemenlis (left, NASA/JPL) and Andrea Molod (NASA/GSFC) exploring the coupled GEOS–MITgcm output using an interactive application on the NAS hyperwall.
David Ellsworth, NASA/Ames

Application Experts Help Improve Ice Sheet Model Performance

- The Applications Performance and Productivity (APP) team helped improve the performance of the Ice Sheet System Model (ISSM) by more than 11 times its previous performance.
  - The ISSM is a new-generation thermo-mechanical ice sheet model designed by the Jet Propulsion Laboratory and University of California Irvine to improve projections of sea level rise over the coming centuries.
  - The ISSM team relied heavily on HECC resources and expertise to perform different simulations for both Greenland and Antarctica, as part of the Ice Sheet Model Intercomparison Project within the Coupled Model Intercomparison Project – phase 6 (CMIP6).
- The APP team provided the ISSM team with performance profiling data and interpretation, which guided the developers on how to modify the code. APP experts then confirmed the impact of those modifications with a new round of profiling. The collaboration went through many rounds and resulted in an 11.9x speedup.
  - The primary benefit came from reduced use of dynamic memory allocation and deallocation.
  - Improved compiler optimizations and load balancing also contributed significantly.

IMPACT: Software performance improvements achieved through collaboration between HECC applications experts and code developers allows many more simulation scenarios to be included in the Ice Sheet System Model ensemble statistics, thus improving uncertainty bounds for sea level rise.

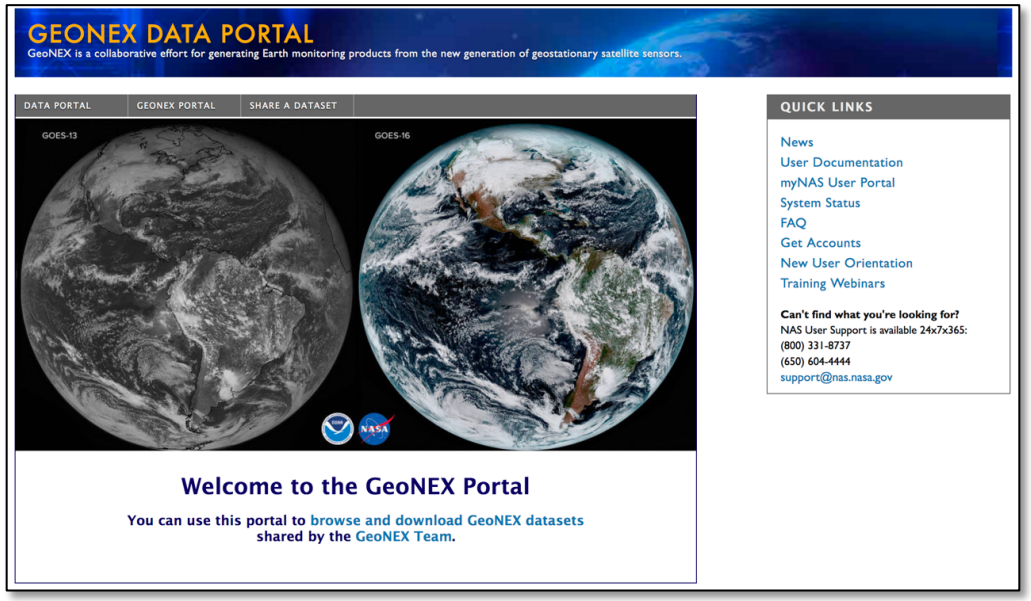


Observed (left) and modeled (right) ice front position for Upernavik Isstrøm C under current conditions. Warm colors are for 2007 to 2017 and cold colors are the model projections for 2017 to 2100. *Mathieu Morlighem, University of California, Irvine*

GeoNEX Dataset Shared Through HECC Data Portal

- The Big Data team worked with the NASA Earth Exchange (NEX) science team to add the GeoNEX dataset to the HECC Data Portal.
- The dataset includes over 120 million files (404 terabytes).
- Data files include gridded top-of-atmosphere reflectance and brightness temperature data products, derived using data from:
  - NASA / National Oceanic and Atmospheric Administration Geostationary Orbital Earth Satellite (GOES)-16 and -17 Advanced Baseline Imagers.
  - Japan's Himawari 8 Geostationary Meteorological Satellite (GMS) Advanced Himawari Imager.
- GeoNEX provides an adaptable processing pipeline to run community-provided algorithms for generating data products related to solar radiation, aerosol optical depth, and more.
  - The pipeline leverages containerized codes for running algorithms on the GeoNEX platform at the NAS facility or on public clouds.
- GeoNEX gridded products will be updated on the Data Portal on a quarterly basis.

IMPACT: HECC's Data Portal provides Earth science researchers with a platform to share large datasets with collaborators and/or the public to promote innovation and scientific discovery.

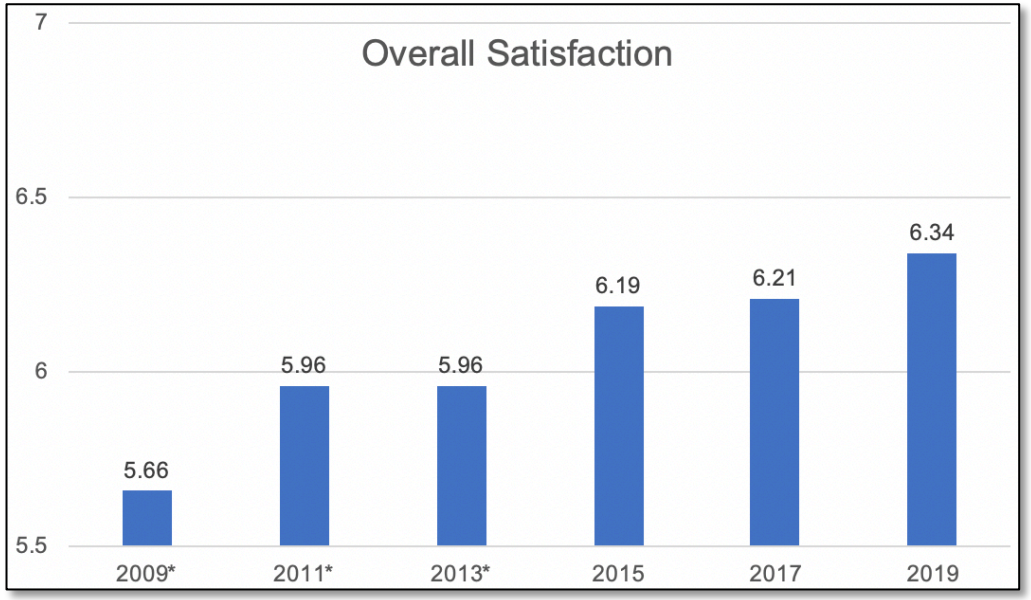


The landing page of the new GeoNEX data portal serves as the entryway to the downloadable dataset files.

Latest Survey Results Help Improve Services to Users

- The 2019 NAS User Survey was open from April 15 through May 10. Users from all NASA mission directorates, as well as academia and industry, participated in the survey.
- The survey received a response rate of about 14.5%, or 231 users, who assessed and provided feedback on 12 HECC service areas.
- Survey scores were very similar to previous years, with Overall Satisfaction scoring 6.34 out of 7. The overall score has risen steadily since the survey began (5.66 in 2009, 6.21 in 2017).
- In addition to quantitative results, users provided many comments that reveal areas of both satisfaction and frustration.
- Two representative quotes from our users:
  - In response to what's outstanding – "Response time and detail of level of responses from queries sent through email or called in over the phone. The staff are both extremely competent and respond to concerns very quickly. "
  - In response to what needs improvement – "Mostly, Pleiades queue times are reasonable, but sometimes it seems jobs can wait 2 weeks, which is a very long time."

IMPACT: The valuable feedback provided by this survey helps the HECC support teams improve services to assist users in achieving their NASA project goals. Periodically surveying scientists and engineers helps teams understand which services users consider most important.



Comparison of Overall Satisfaction scores on a 7-point scale over the past six surveys.

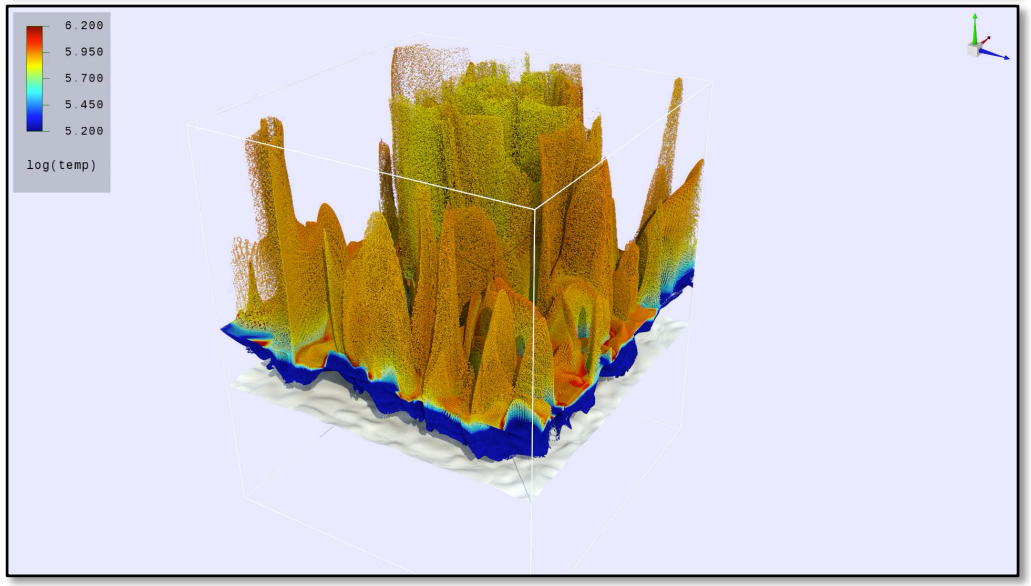
*Calibrated from 5-point scale.

Modeling the Solar Corona to Study Sources of Space Weather Disturbances*

- To better understand energy accumulation and release in the solar atmosphere, researchers at NASA Ames used Pleiades and Electra to perform high-resolution, 3D radiative magnetohydrodynamic simulations that reproduce the structure and dynamics of the solar corona.
- The study helps scientists interpret observations from NASA's Solar Dynamics Observatory, IRIS, and Hinode missions.
  - Simulation results reveal that initially uniform weak magnetic fields are greatly amplified due to small-scale dynamo action below the visible surface of the Sun and cause the spontaneous formation of tornado-like plasma structures and eruptions.
  - The strongest helical flows originate in strong, 1-kiloGauss magnetic field patches formed on the solar surface.
  - The simulations also reveal many important details that are unresolved in observational data, such as the Kelvin-Helmholtz instability of the magnetic structures and plasma downflows in the corona.
- HECC teams provided several critical services needed for this project, including 24/7 user support, visualization, and computer science expertise.

** HECC provided supercomputing resources and services in support of this work.*

IMPACT: Realistic modeling of the Sun's corona is critical for understanding the origins of space weather and predicting its impacts on the near-Earth space environment; and helps prepare for the Artemis Program and human space exploration beyond low-Earth orbit.



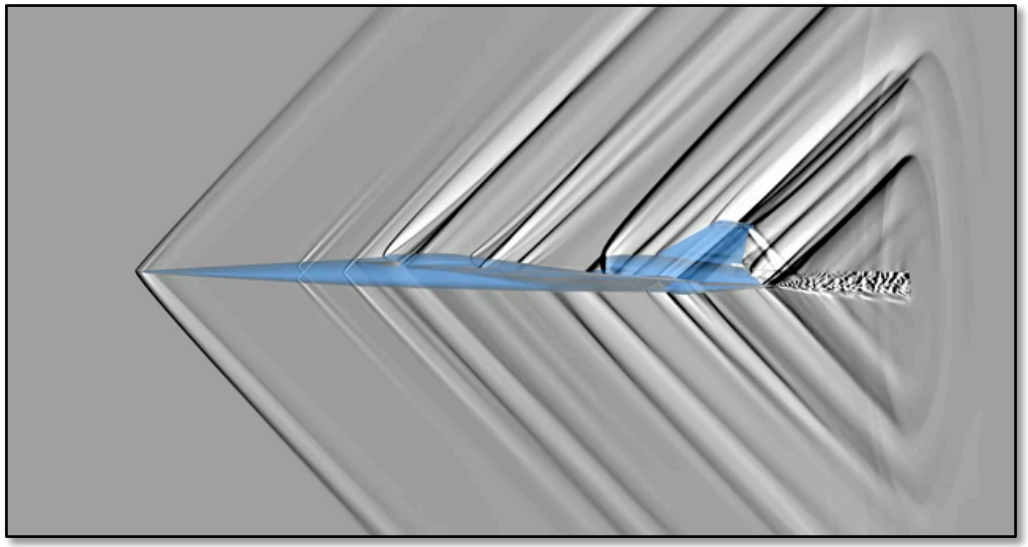
Video showing the evolution of the solar plasma temperature about 6,200 miles above the Sun's surface. The dark structure in the middle is an evolving funnel-like magnetic domain. Disturbances moving across the domain are shocks, which also contribute to coronal heating. *Irina Kitiashvili, Timothy Sandstrom, NASA/Ames*

Minimizing Sonic Boom through Simulation-Based Design: The X-59 Airplane*

- Aerospace engineers at NASA Ames ran high-fidelity computational fluid dynamics (CFD) simulations on Pleiades, Electra, and Endeavour to help shape the design of NASA's upcoming X-59 Quiet SuperSonic Technology X-plane.
- NASA's production-level Cart3D simulation package for CFD was used extensively to determine the pressure field near the aircraft and evaluate the ground noise carpet of each major design evolution of the X-59.
- Cart3D was coupled with an atmospheric propagation solver to estimate the noise level on the ground; and with uncertainty quantification tools to provide uncertainty estimates in the pressure signatures due to variations in the aircraft's operating conditions and configuration.
- The simulations contributed to many design improvements such as reducing the noise generated by the nose of the aircraft, instrumentation probes, and secondary-air-systems inlets. Cart3D is also used to support supersonic wind tunnel tests.

**HECC provided supercomputing resources and services in support of this work.*

IMPACT: These simulations, run on HECC resources, support one of NASA's six Strategic Thrusts for the agency's Aeronautics Research Mission Directorate: "Innovation in Commercial Supersonic Aircraft."



Video from a Cart3D simulation showing the complex shock system of NASA's X-59. Dark and bright regions represent shockwaves and expansions, respectively. Weaker shocks propagate from the lower surface of the aircraft, quieting sonic booms to sonic thumps on the ground. *Marian Nemec, Michael Aftosmis, NASA/Ames*

HECC Facility Tours in December 2019

- HECC hosted 5 tour groups in December; guests learned about the agency-wide missions being supported by HECC assets, and also viewed the D-Wave 2000Q quantum system. Visitors this month included:
  - Graduate students and a professor from the University of Washington, some of whom have NAS accounts and have never visited the facility.
  - Oleg Alexandrov and Scott McMichael, NASA contractors who make significant use of HECC computational resources, visited while in the San Francisco Bay Area for the American Geophysical Union conference.
  - Stephen Shih, NASA Associate Administrator of the Office of Diversity and Equal Opportunity, who was visiting Ames Research Center.
  - A team of administrators and professors from the University of Colorado Boulder.
  - Students from San Jose State University's Aerospace Engineering program.

A group of grad students from the University of Washington get a behind-the-scenes look at HECC supercomputing resources from Cetin Kiris, Computational Aerosciences Branch Chief in the NASA Advanced Supercomputing Division. *Gina Morello*

Papers

- "**Enhanced Upward Heat Transport at Deep Submesoscale Ocean Fronts**," L. Siegelman, et al., Nature: Geoscience (2019), December 2, 2019. *
  https://www.nature.com/articles/s41561-019-0489-1
- "**KELT-25b and KELT-26b: A Hot Jupiter and a Substellar Companion Transiting Young A-stars Observed by TESS**," R. Rodríguez Martinez, et al., arXiv:1912.01017 [astro-ph.EP], December 2, 2019. *
  https://arxiv.org/abs/1912.01017
- "**Global 3D Radiation Magnetohydrodynamic Simulation for FU Ori's Accretion Disk and Observational Signatures of Magnetic Fields**," Z. Zhu, Y.-F. Jiang, J. Stone, arXiv:1912.01632 [astro-ph.EP], December 3, 2019. *
  https://arxiv.org/abs/1912.01632
- "**Runaway Coalescence of Pre-Common-Envelope Stellar Binaries**," M. MacLeod, A. Loeb, arXiv:1912.05545 [astro-ph.SR], December 11, 2019. *
  https://arxiv.org/abs/1912.05545
- "**Seasonal Characteristics of Model Uncertainties from Biogenic Fluxes, Transport, and Large-Scale Boundary Inflow in Atmospheric CO_2 Simulations Over North America**," S. Feng, et al., Journal of Geophysical Research: Atmospheres (Early Access), published online December 11, 2019. *
  https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2019JD031165

** HECC provided supercomputing resources and services in support of this work*

Papers (cont.)

- "**GJ 1252 b: A 1.2 $R_{\oplus}$ Planet Transiting an M-Dwarf at 20.4 pc**," A. Shporer, et al., arXiv:1912.05556 [astro-ph.EP], December 11, 2019. *
  https://arxiv.org/abs/1912.05556
- "**First Provisional Land Surface Reflectance Product from Geostationary Satellite Himawari-8 AHI**," S. Li, et al., Remote Sensing, vol. 11, issue 24, Special Issue: Earth Monitoring from a New Generation of Geostationary Satellites, December 12, 2019. *
  https://www.mdpi.com/2072-4292/11/24/2990
- "**TESS Phase Curve of the Hot Jupiter WASP-19b**," I. Wong, et al., arXiv:1912.06773 [astro-ph.EP], December 14, 2019. *
  https://arxiv.org/abs/1912.06773
- "**Detection and Characterisation of Oscillating Red Giants: First Results from the TESS Satellite**," V. Silva Aguirre, et al., arXiv:1912.07604 [astro-ph.SR], December 16, 2019. *
  https://arxiv.org/abs/1912.07604
- "**Exploring Bistability in the Cycles of the Solar Dynamo Through Global Simulations**," L. Matilsky, J. Toomre, arXiv:1912.08158 [astro-ph.SR], December 17, 2019. *
  https://arxiv.org/abs/1912.08158

** HECC provided supercomputing resources and services in support of this work*

Papers (cont.)

- "**A Mass Threshold for Galactic Gas Discs by Spin Flips**," A. Dekel, et al., arXiv:1912.08213 [astro-ph.GA], December 17, 2019. *
  https://arxiv.org/abs/1912.08213
- "**Sensitivity of the Northeast Greenland Ice Stream to Geothermal Heat**," S. Smith-Johnson, et al., Journal of Geophysical Research: Earth Surface, December 20, 2019. *
  https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1029/2019JF005252
- "**TOI 564 b and TOI 905 b: Grazing and Fully Transiting Hot Jupiters Discovered by TESS**," A. Davis, et al., arXiv:1912.10186 [astro-ph.EP], December 21, 2019. *
  https://arxiv.org/abs/1912.10186

** HECC provided supercomputing resources and services in support of this work*

Presentations

- **American Geophysical Union (AGU) Fall Meeting,** San Francisco, CA, December 9–13, 2019.
  - "**NASA's Digital Transformation (DT) Initiative**," B. Biegel, J.-F. Barthelemy.*
    https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20190033978.pdf
  - "**Solar Activity Modeling: From Subgranular Scales to the Solar Cycles**," I. Kitiashvili, A. Wray, V. Sadykov, A. Kosovichev, N. N. Mansour.*
    https://agu.confex.com/agu/fm19/meetingapp.cgi/Paper/600129
  - "**Cluster Analysis of Spectroscopic Line Profiles in the IRIS Observations and RMHD Simulations of the Solar Atmosphere**," V. Sadykov, I. Kitiashvili, A. Kosovichev.*
    https://agu.confex.com/agu/fm19/meetingapp.cgi/Paper/507218
  - "**Asteroid Impact Crater Sizes in Water**," D. Robertson, P. Register, B. Nguyen, C. Rumpf.*
    https://agu.confex.com/agu/fm19/meetingapp.cgi/Paper/518325
  - "**An Automated Bolide Detection and Lightcurve Pipeline for GOES Geostationary Lightning Mapper**," J. Smith, C. Rumpf, R. Morris, R. Longenbaugh, J. Dotson, C. Henze, D. Mathias.
    https://agu.confex.com/agu/fm19/meetingapp.cgi/Paper/567787
  - "**Extracting Bolide Light Curves from GOES GLM Data**," R. Morris, J. Smith, J. Dotson, C. Rumpf, R. Longenbaugh, C. Henze, D. Mathias.
    https://agu.confex.com/agu/fm19/meetingapp.cgi/Paper/620917
  - "**Using Deep Learning to Automate Inference of Meteoroid Pre-Entry Properties**," A. Tarano, J. Gee, L. Wheeler, S. Close, D. Mathias.*
    https://agu.confex.com/agu/fm19/meetingapp.cgi/Paper/519737

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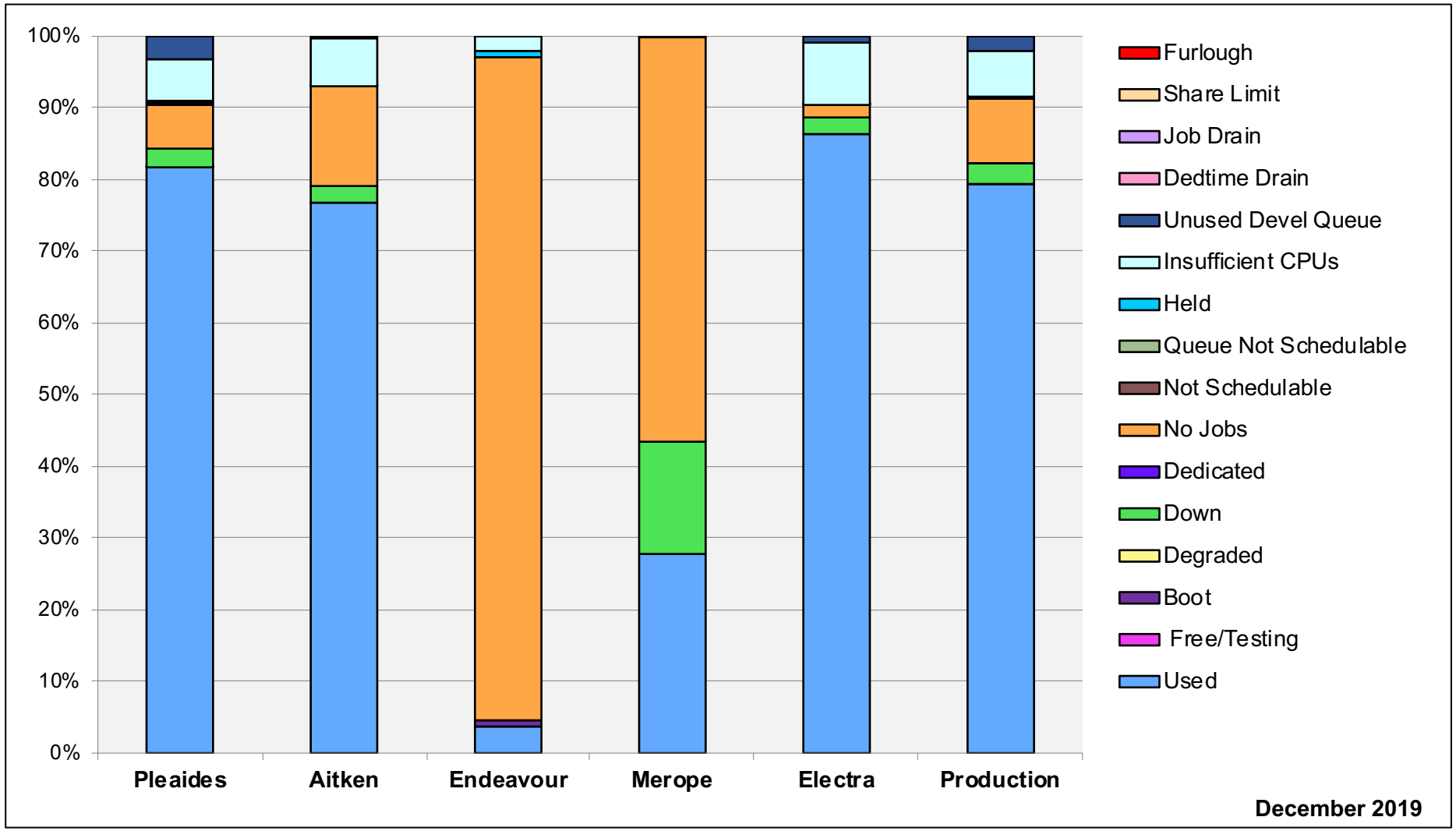
News and Events

- **Media Coverage of SC19 Demo: Simulating the Water Cycle and Cloud Formation on Mars, M. Kahre, NASA Ames**
  - **NASA Simulates the Clouds on Mars Using a Supercomputer**, *Digital Trends*, December 1, 2019. https://www.digitaltrends.com/cool-tech/nasa-mars-cloud-simulation/
  - **Image: A Cloudy Martian Night Through the Eyes of a Supercomputer**, *Phys.org*, December 4, 2019. https://phys.org/news/2019-12-image-cloudy-martian-night-eyes.html
- **It's a Wrap! NAS Science and Engineering Shines at Supercomputing Show**, *NAS Feature*, December 20, 2019—NASA Advanced Supercomputing (NAS) Division researchers captivated audiences at SC19 with spectacular images and videos that told the story of their science and engineering achievements made possible by high-performance computing. https://www.nas.nasa.gov/publications/articles/feature_NAS_SC19_wrapup.html

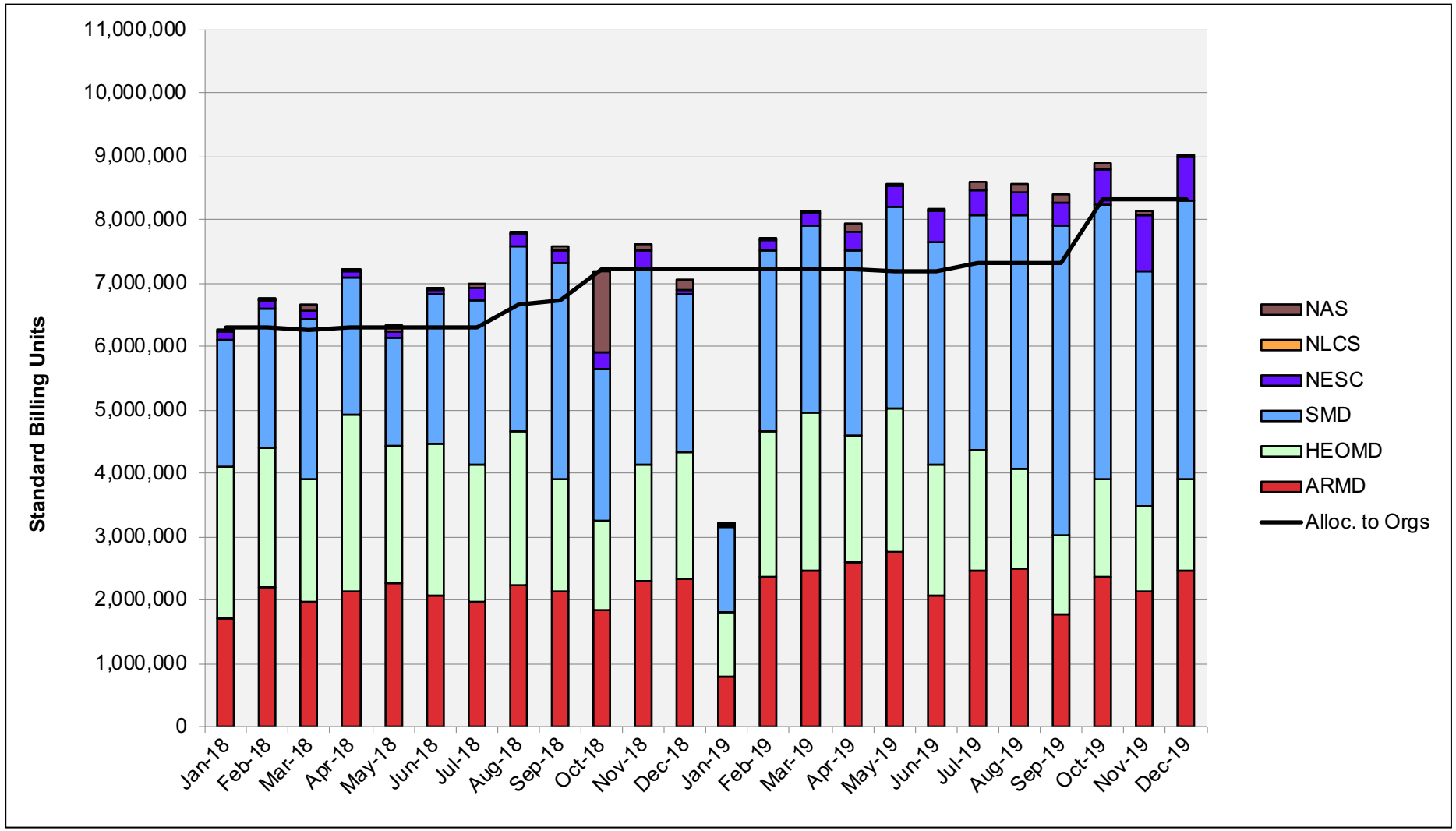
News and Events: Social Media

- **Coverage of NAS Stories**
  - Ames 80th Anniversary: Supercomputing at Ames
    - NASA Ames: Facebook: Dec .18 – Ames supercomputing history fun fact, Twitter 56 retweets, 236 favorites
    - NASA Supercomputing: Facebook: Dec. 20 – Repost of above, with NAS Division details, 406 users reached, 25 engagements, 8 likes
  - SC19 Wrap-Up (NAS Feature)
    - NAS Supercomputing: Twitter 4 retweets, 10 favorites
    - NASA Supercomputing: Twitter 3 favorites
    - NASA Supercomputing: Facebook 662 users reached, 58 engagements, 11 likes, 5 shares
  - X-57 ”Maxwell” Concept Aircraft
    - NAS Supercomputing: Twitter 1 retweet, 6 favorites

HECC Utilization



HECC Utilization Normalized to 30-Day Month



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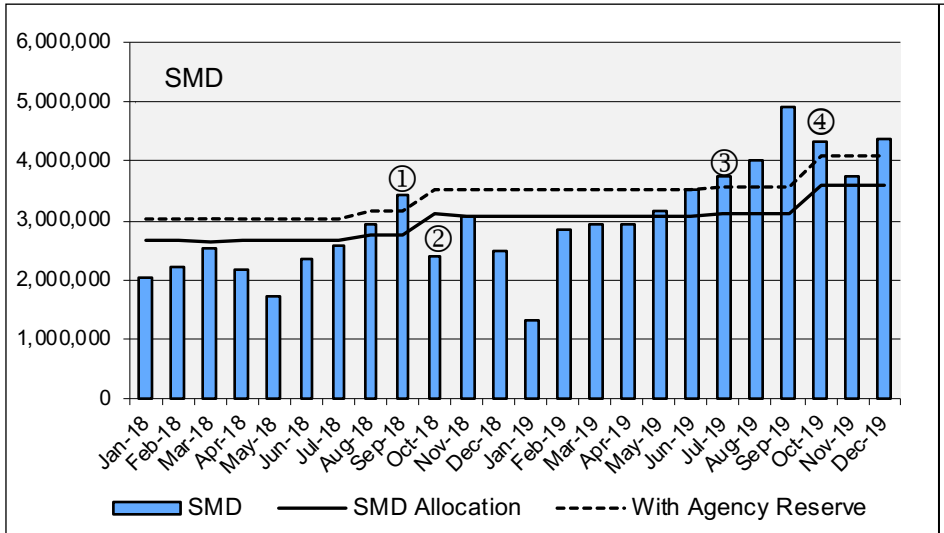
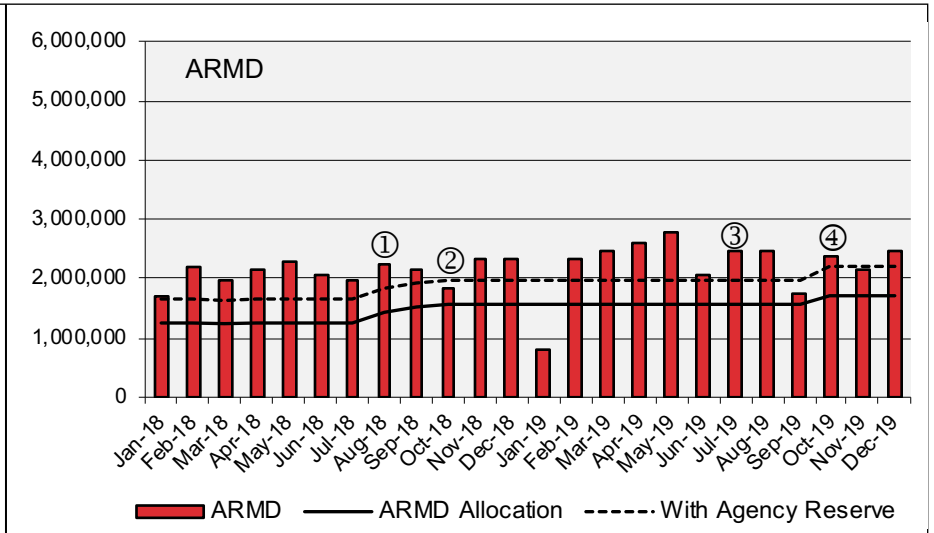
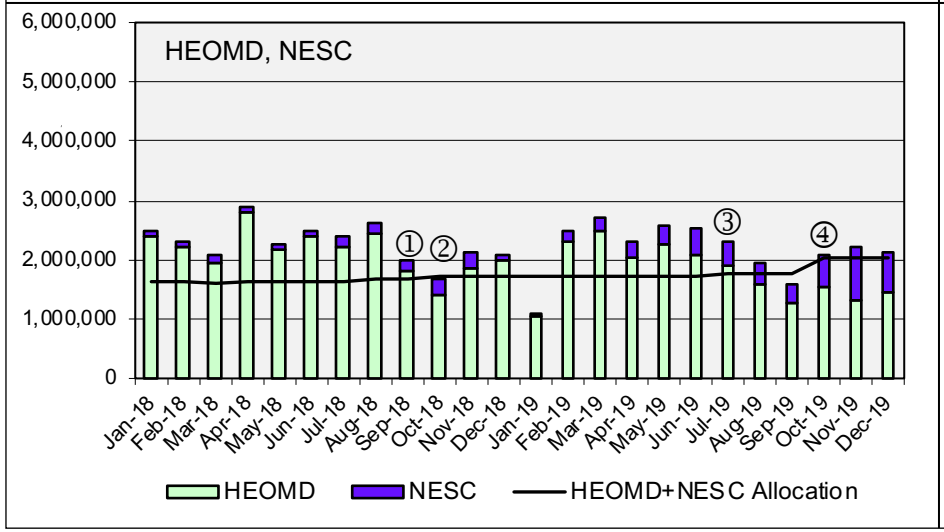






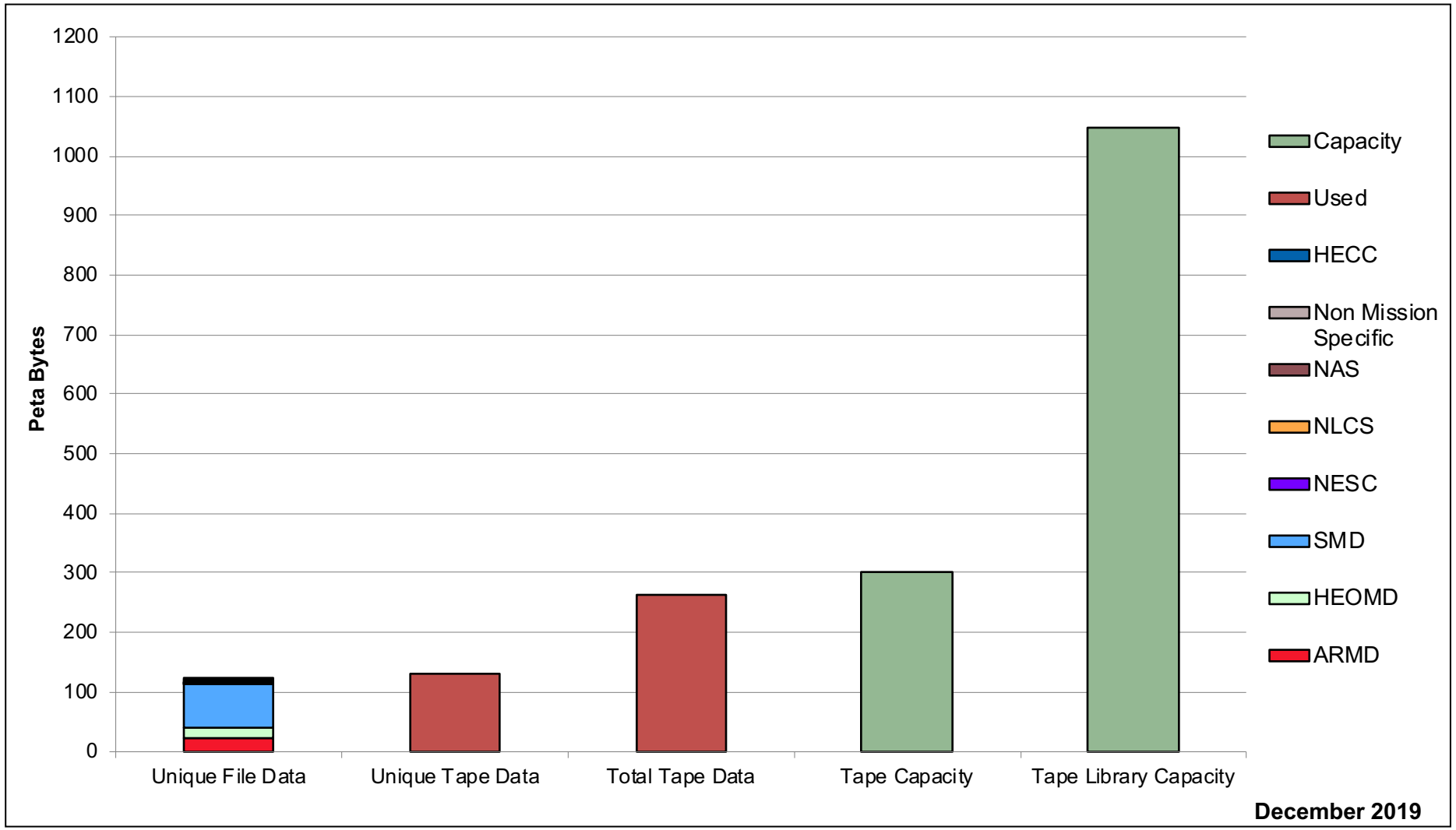
① 4 Skylake E cells (16 D Rack Equivalence) added to Electra

② 2 Skylake E cells (8 D Rack Equivalence) added to Electra; 1 rack is dedicated to ARMD

③ 2 Skylake E cells (8 D Rack Equivalence) added to Electra; 1 rack is dedicated to SMD

④ Skylake Tesla GPU V100 Nodes installed

Tape Archive Status



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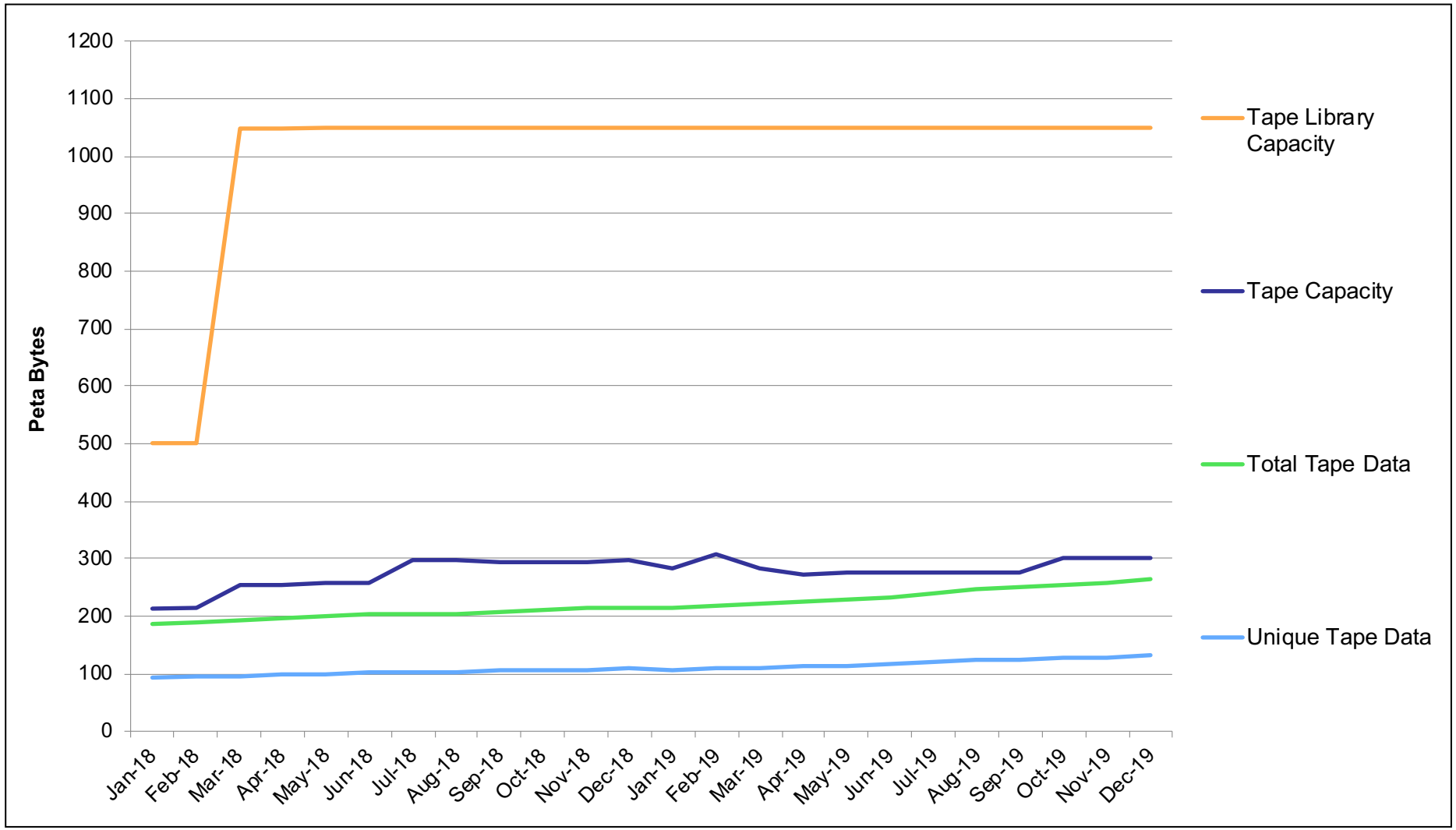
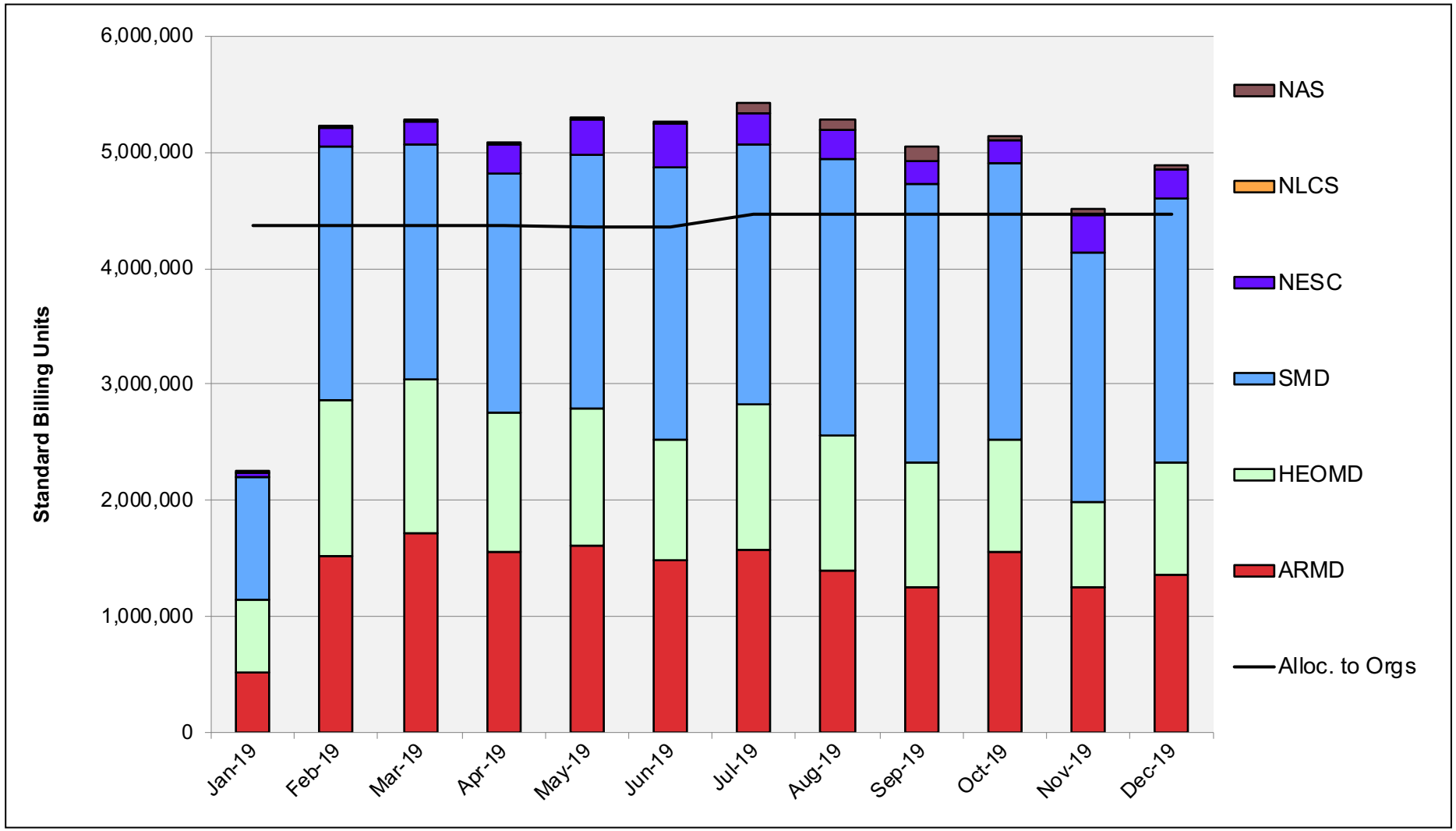
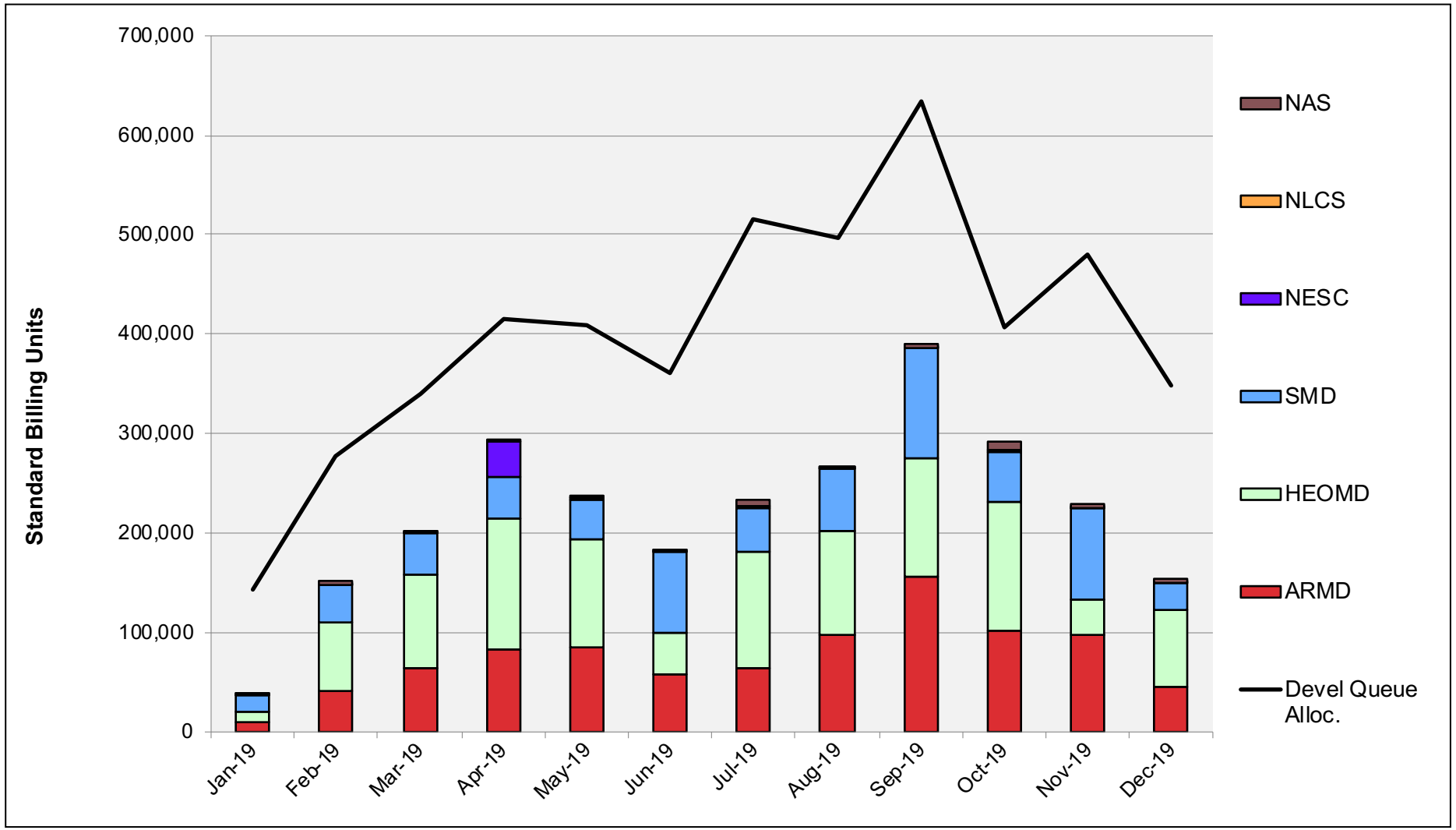


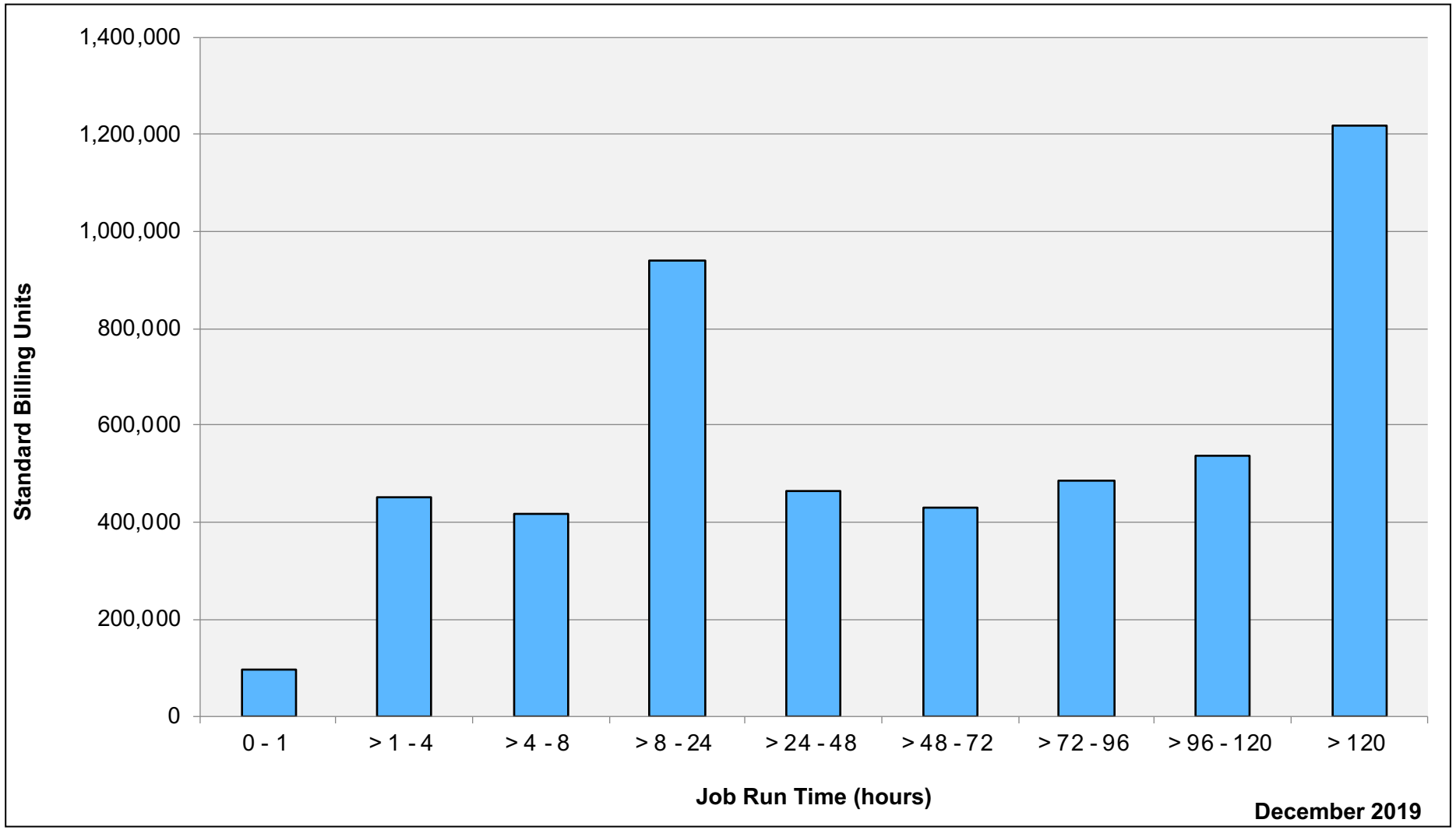
Pleiades: SBUs Reported, Normalized to 30-Day Month



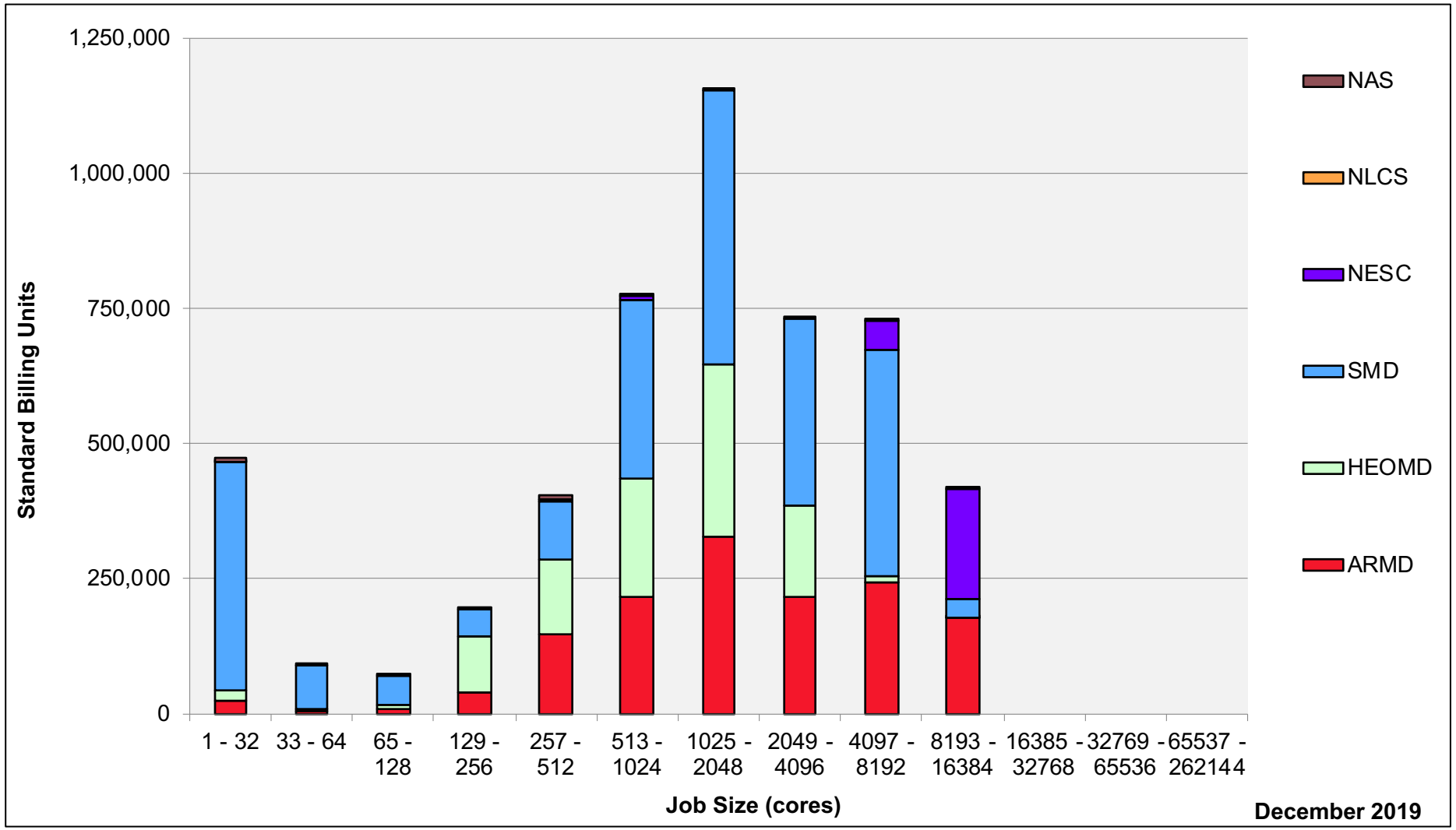
Pleiades: Devel Queue Utilization



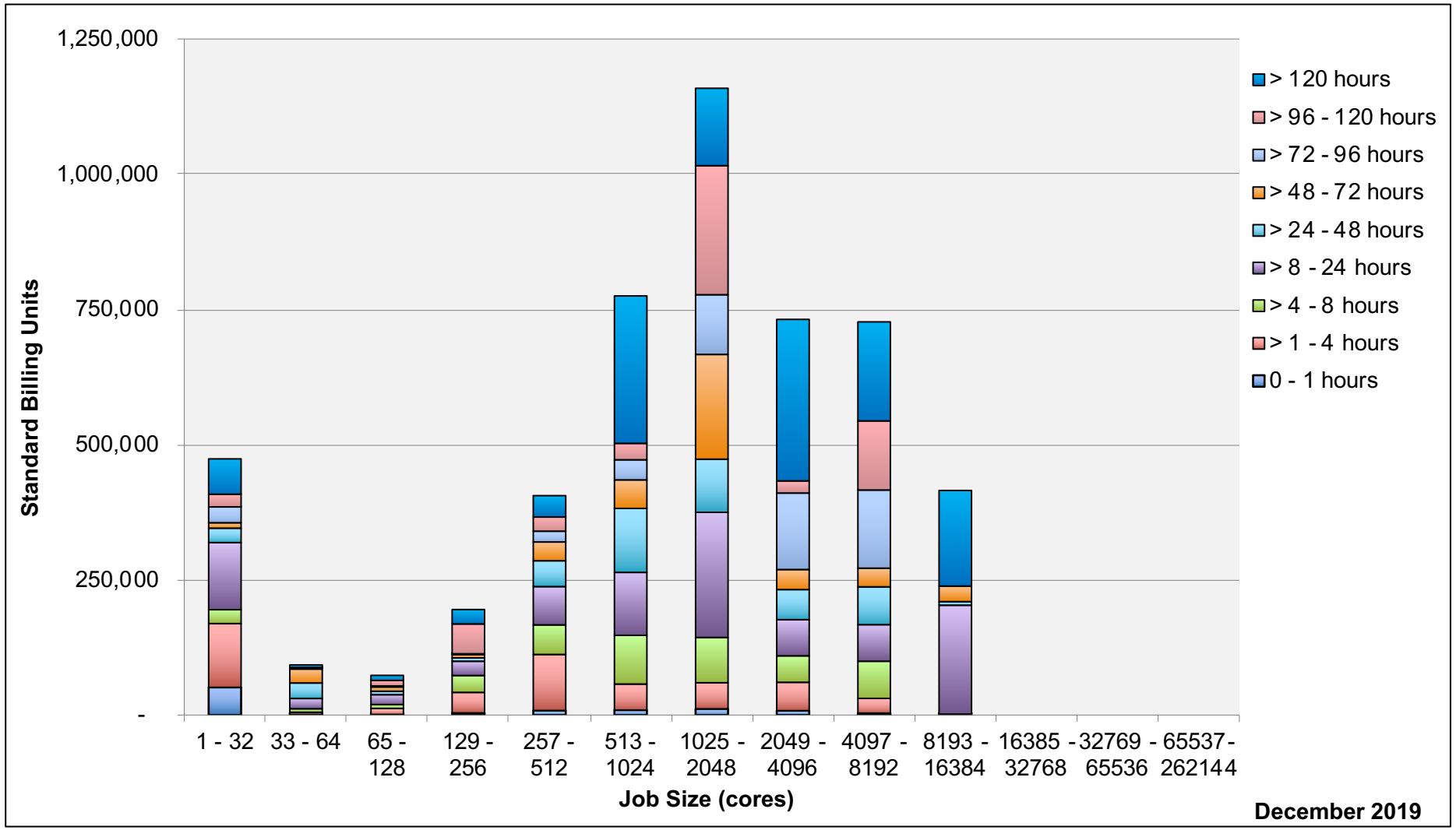
Pleiades: Monthly Utilization by Job Length



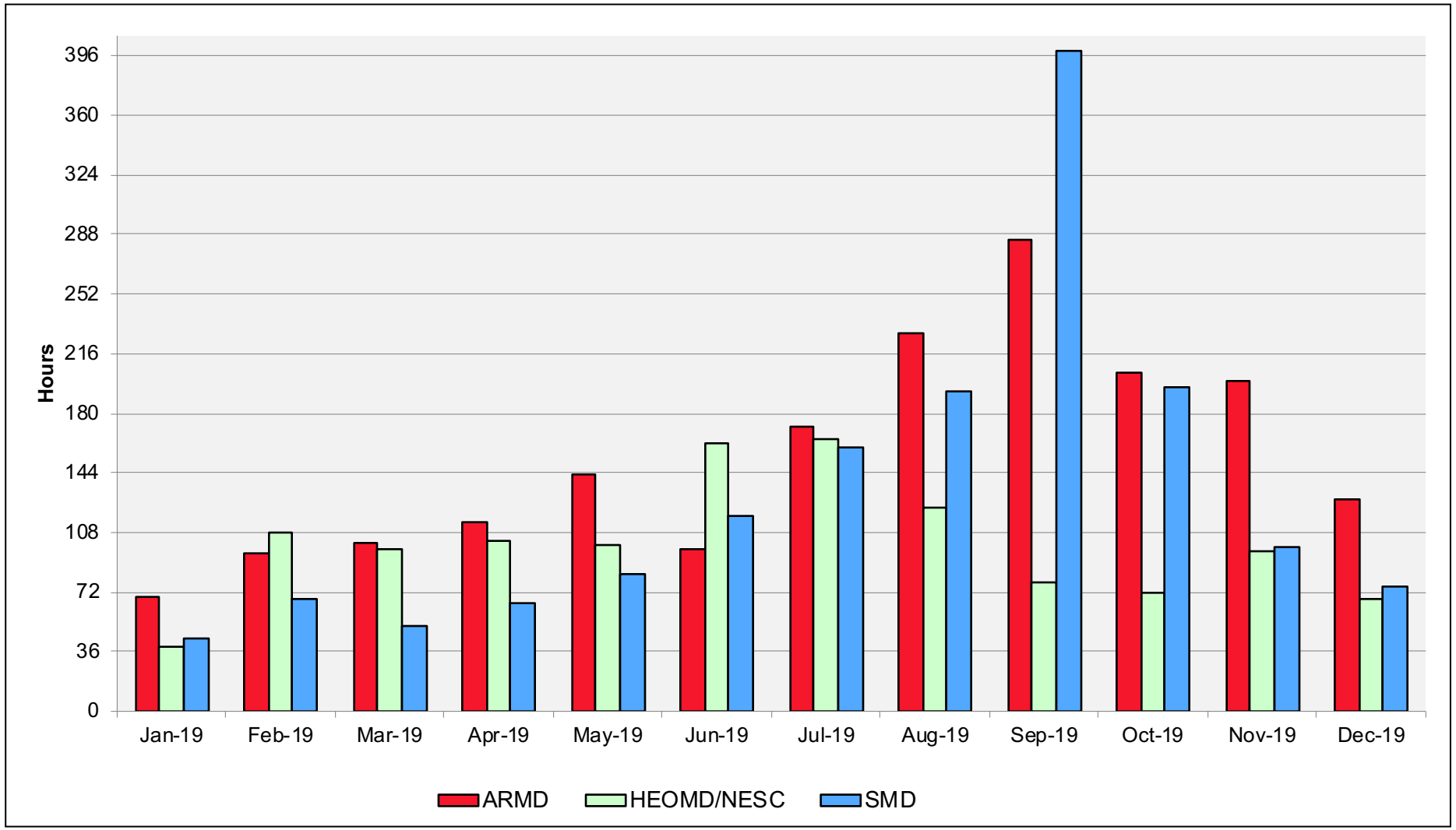
Pleiades: Monthly Utilization by Job Length



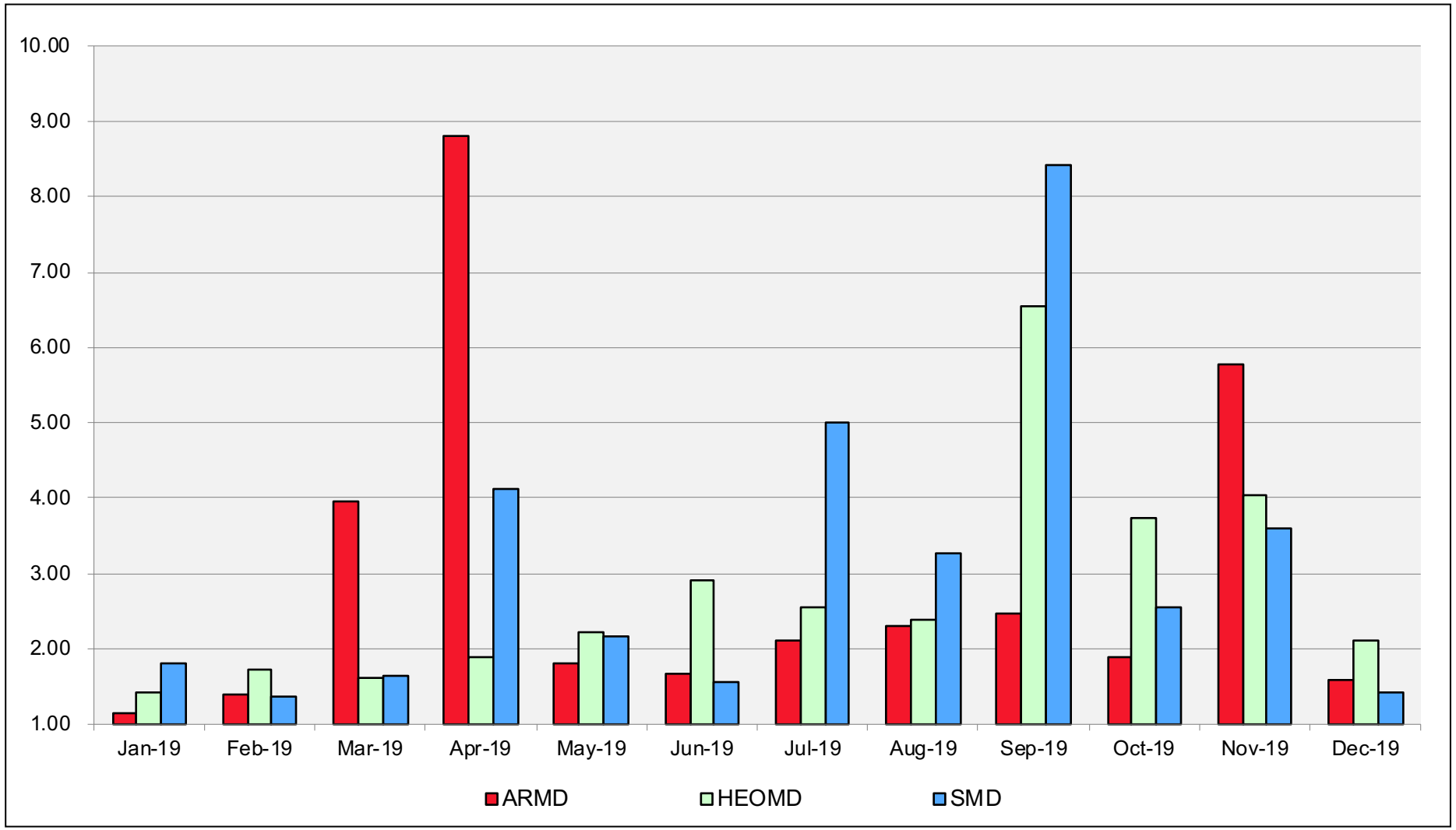
Pleiades: Monthly Utilization by Size and Length



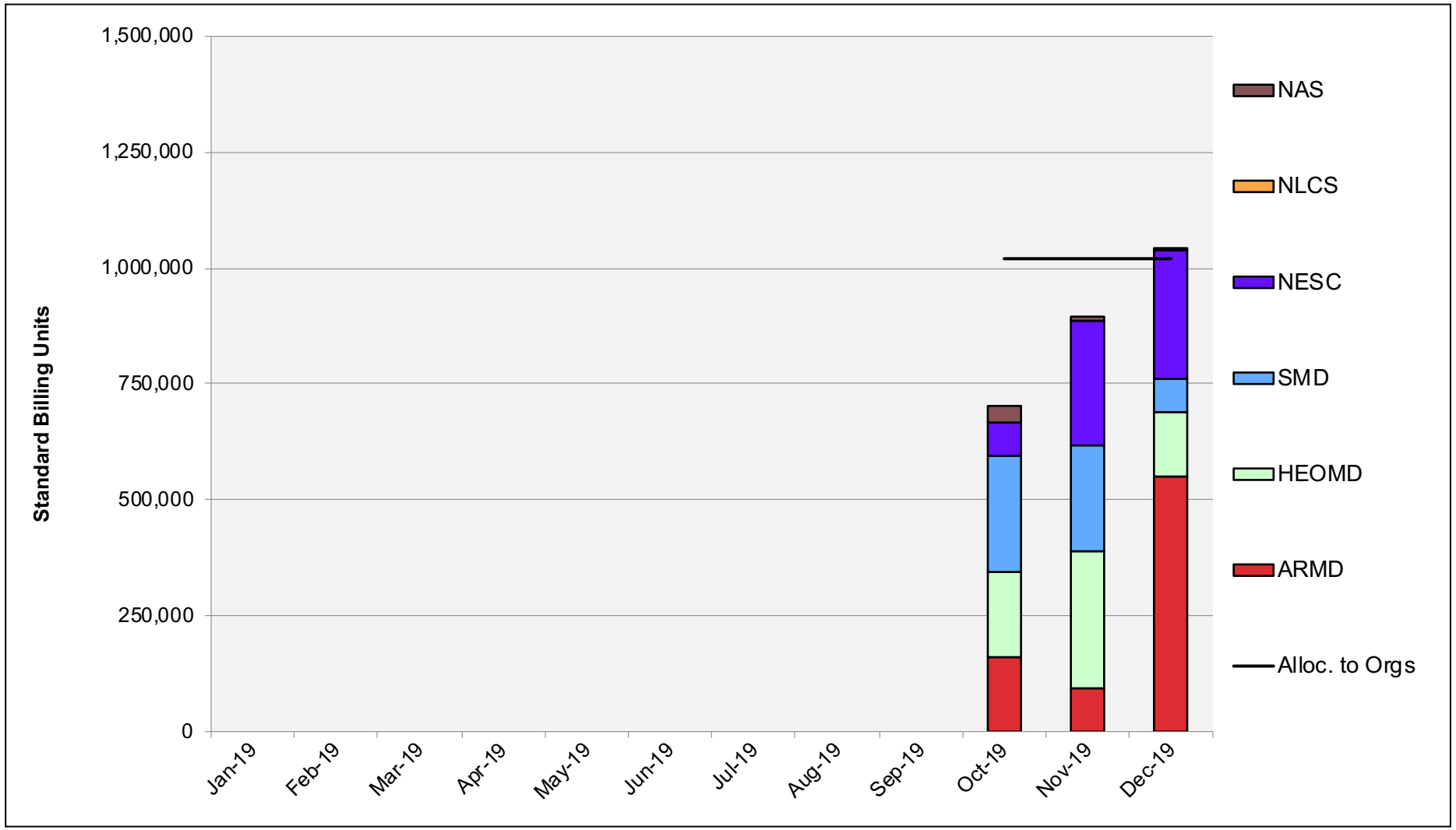
Pleiades: Average Time to Clear All Jobs



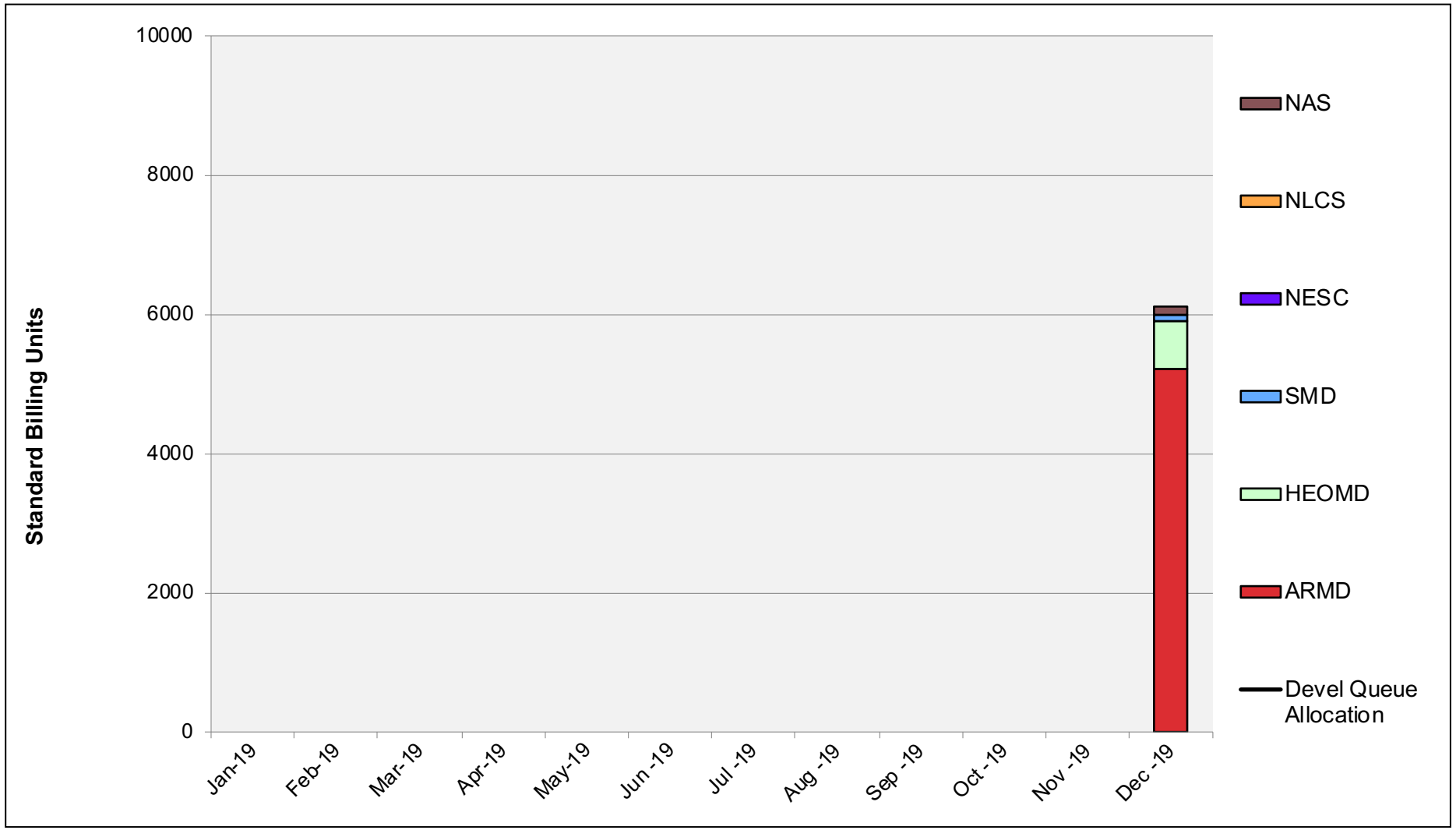
Pleiades: Average Expansion Factor



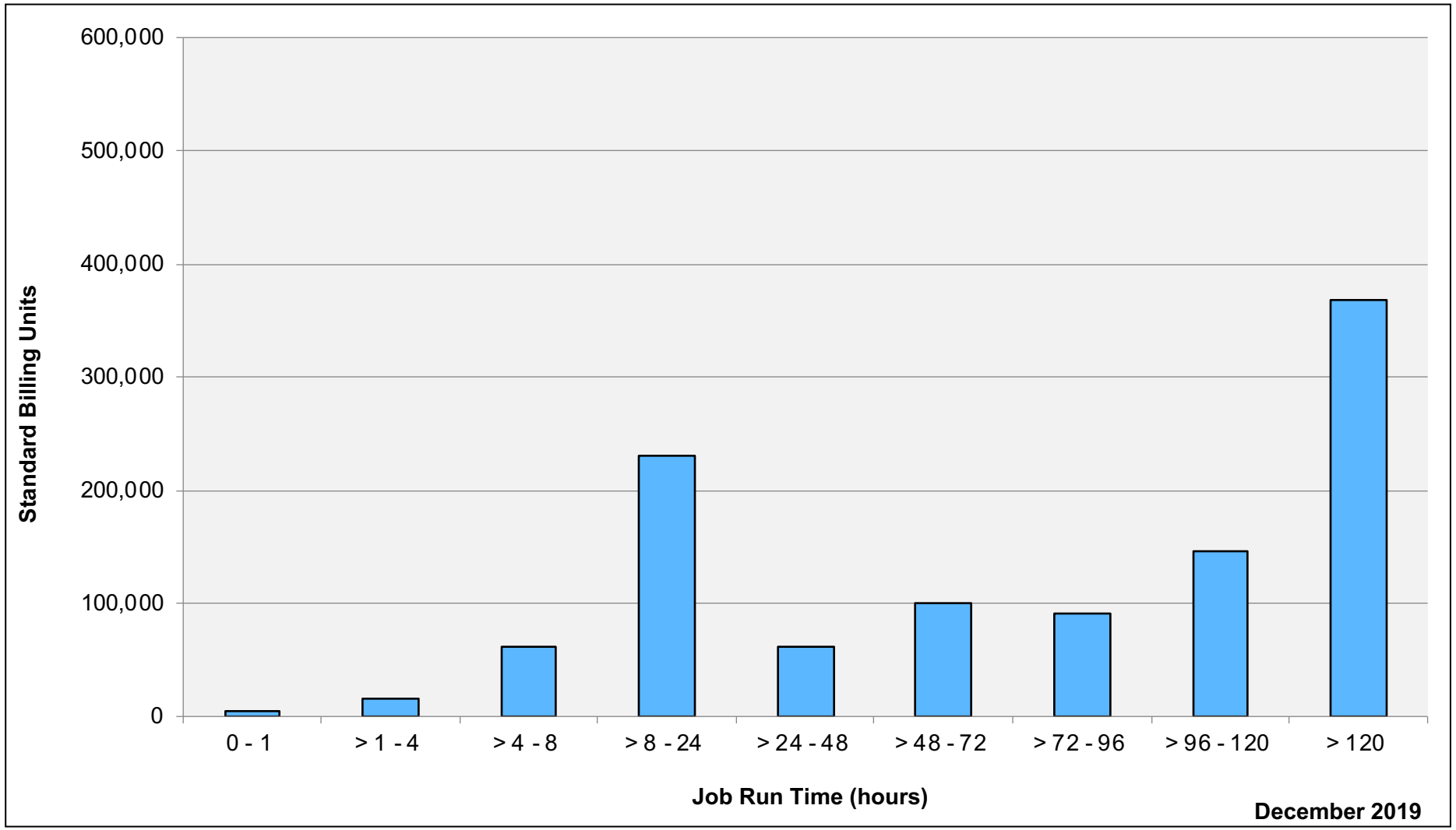
Aitken: SBUs Reported, Normalized to 30-Day Month



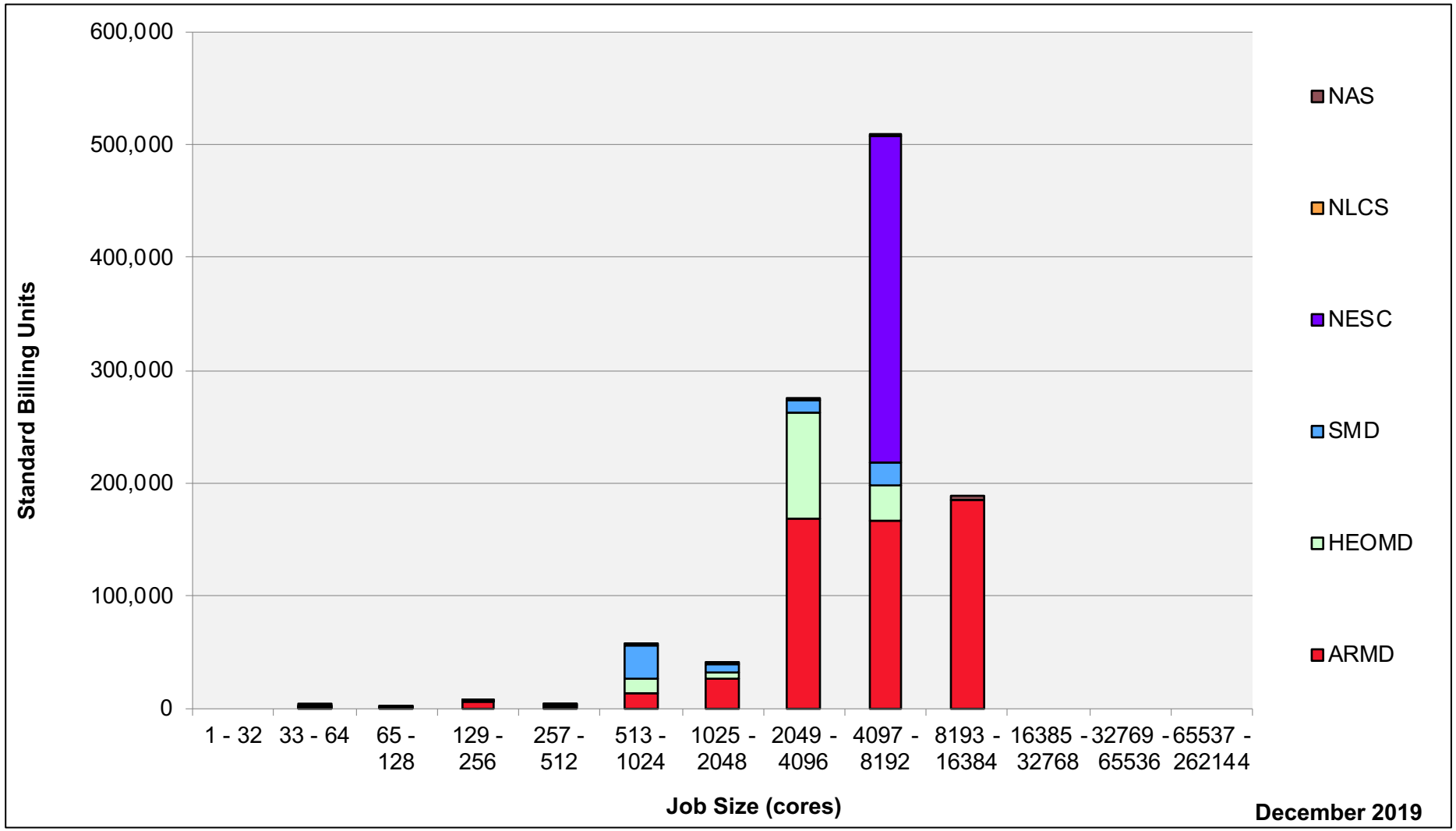
Aitken: Devel Queue Utilization



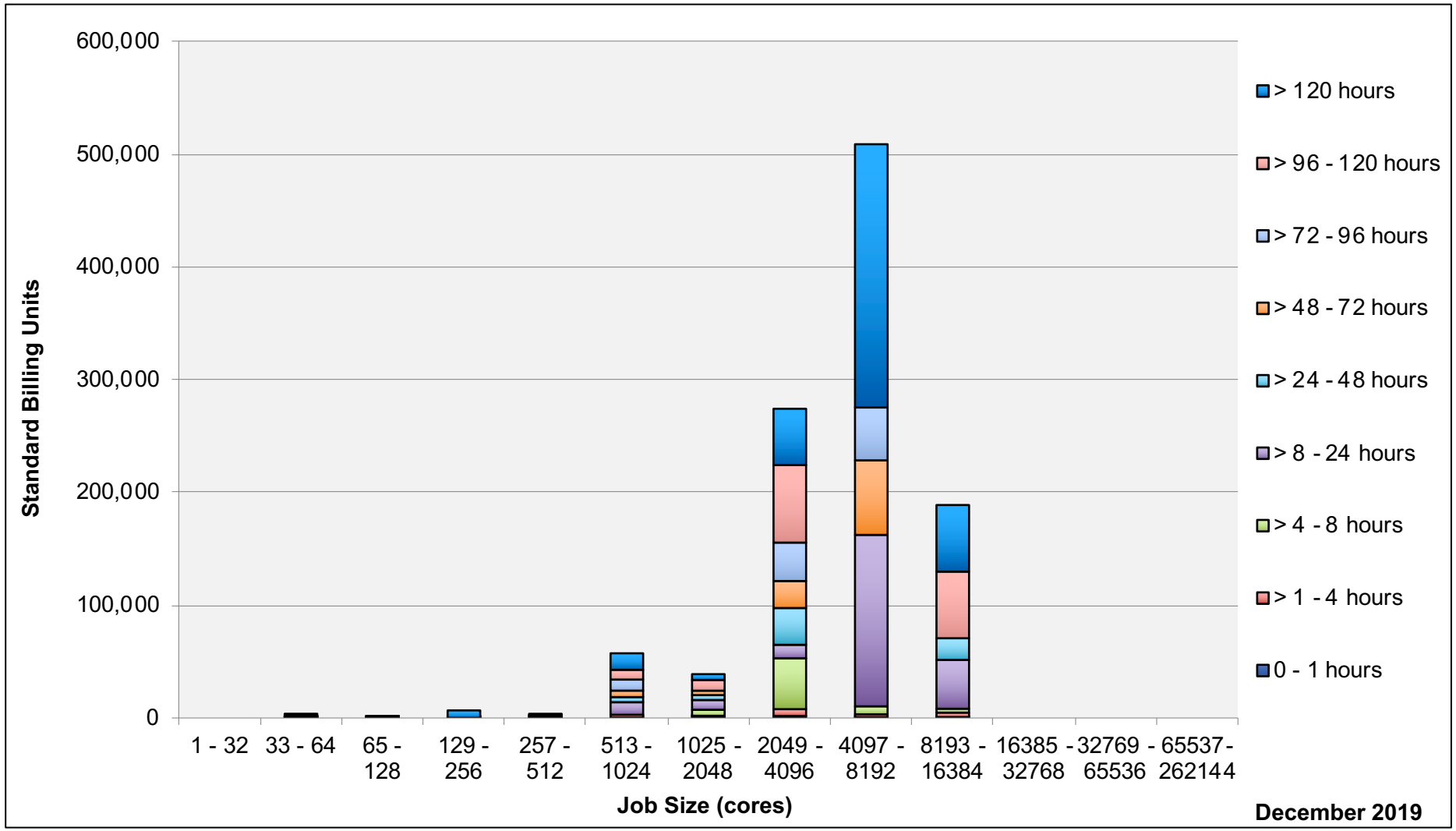
Aitken: Monthly Utilization by Job Length



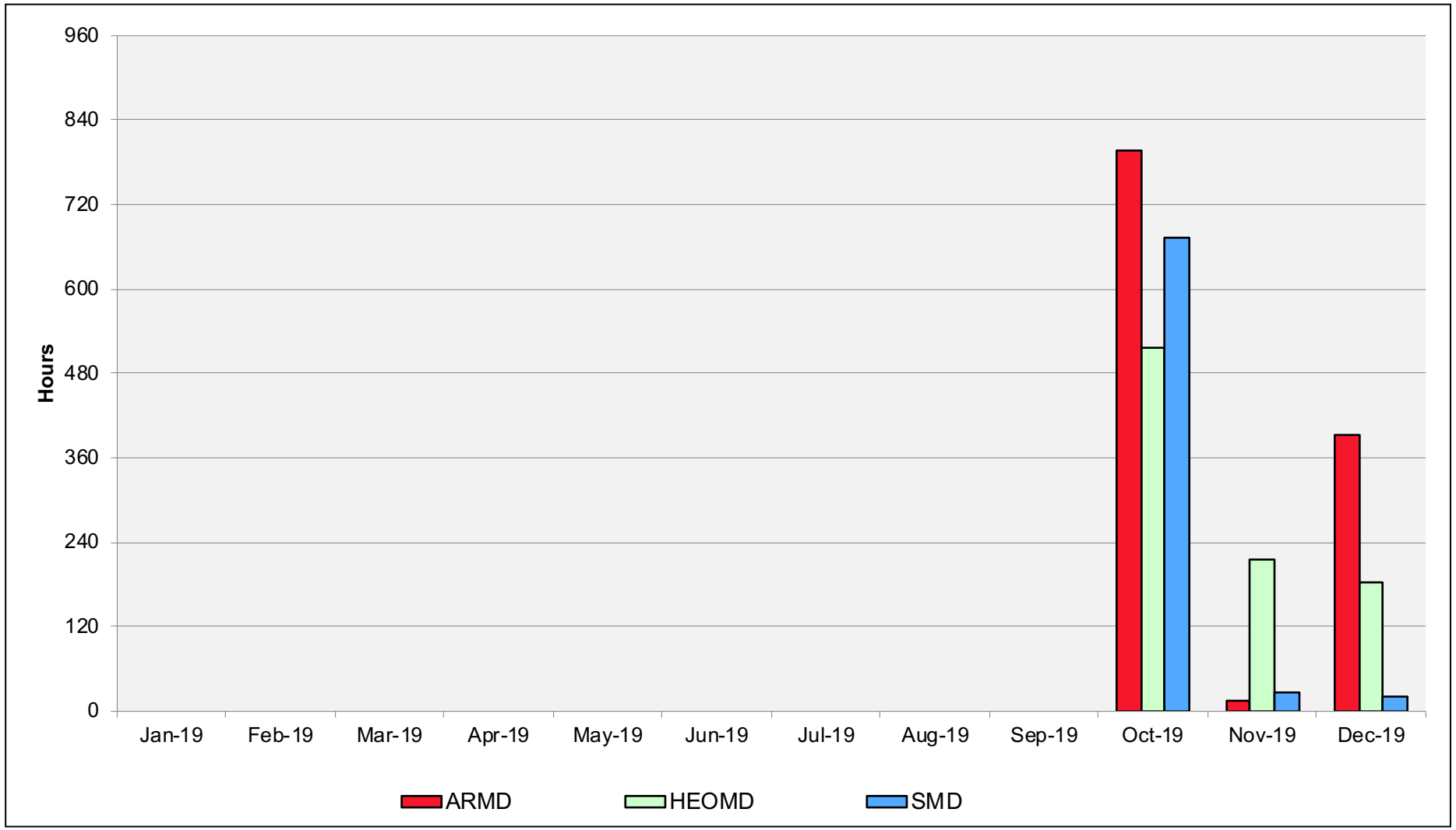
Aitken: Monthly Utilization by Job Length



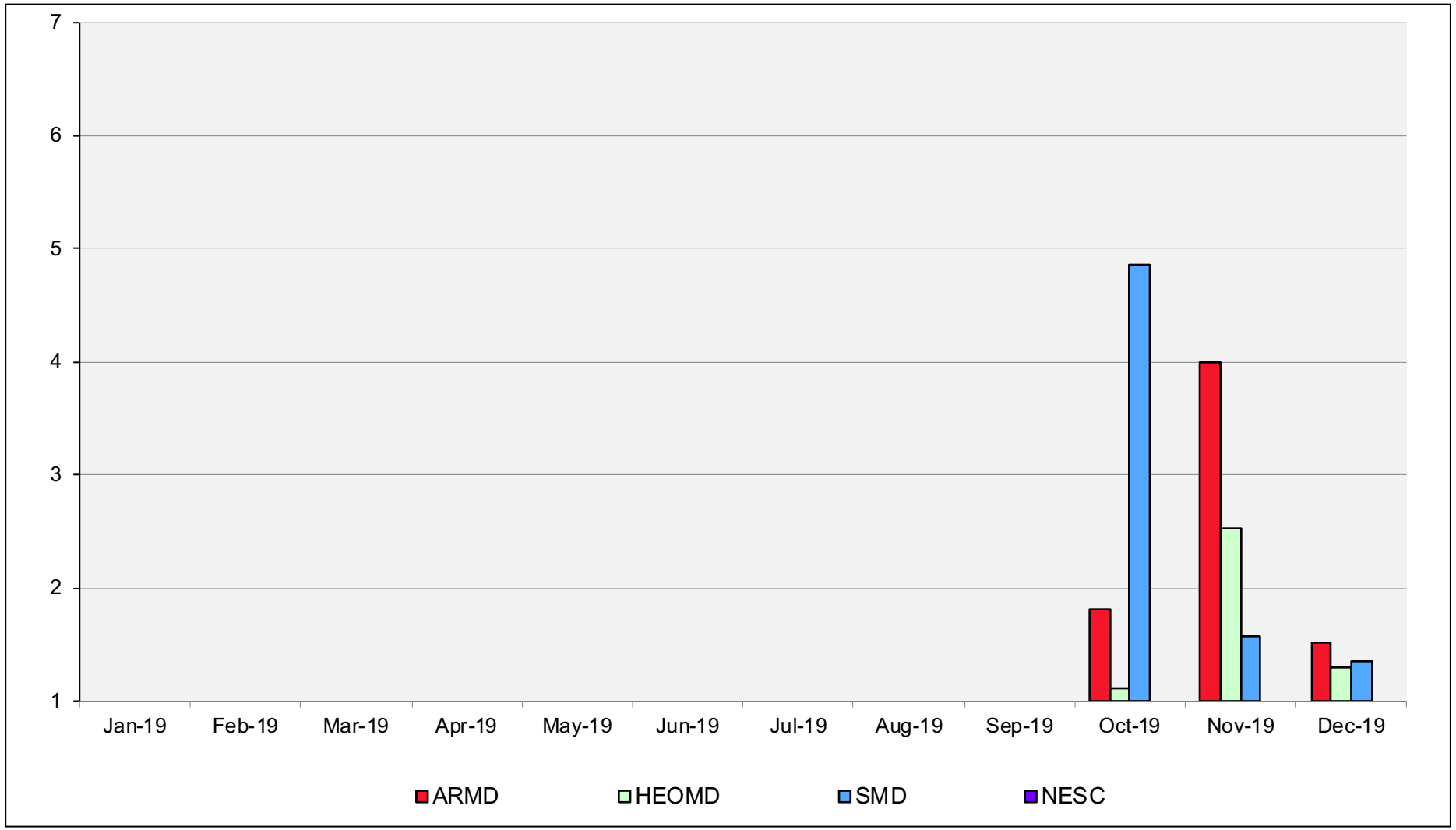
Aitken: Monthly Utilization by Size and Length



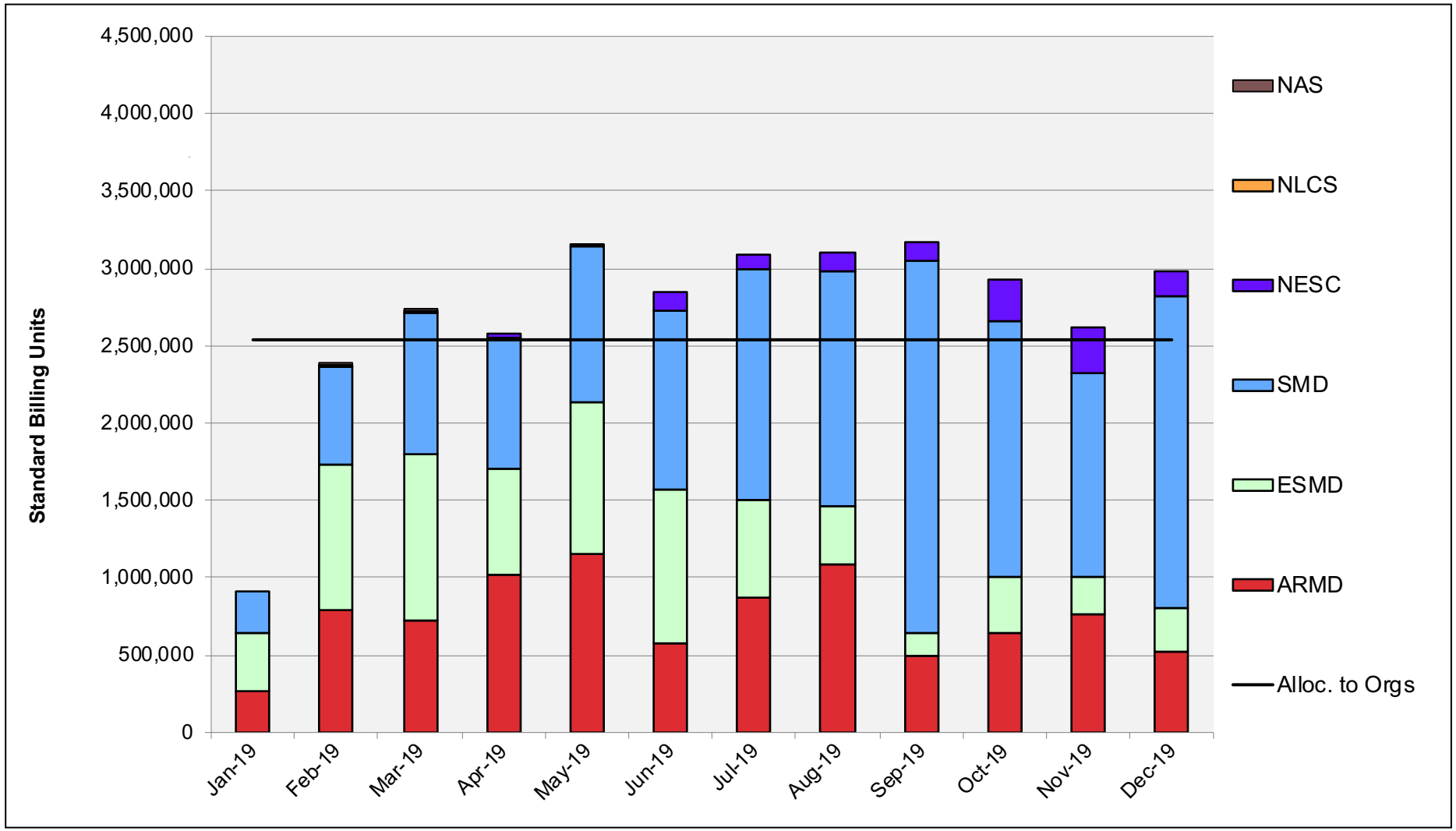
Aitken: Average Time to Clear All Jobs



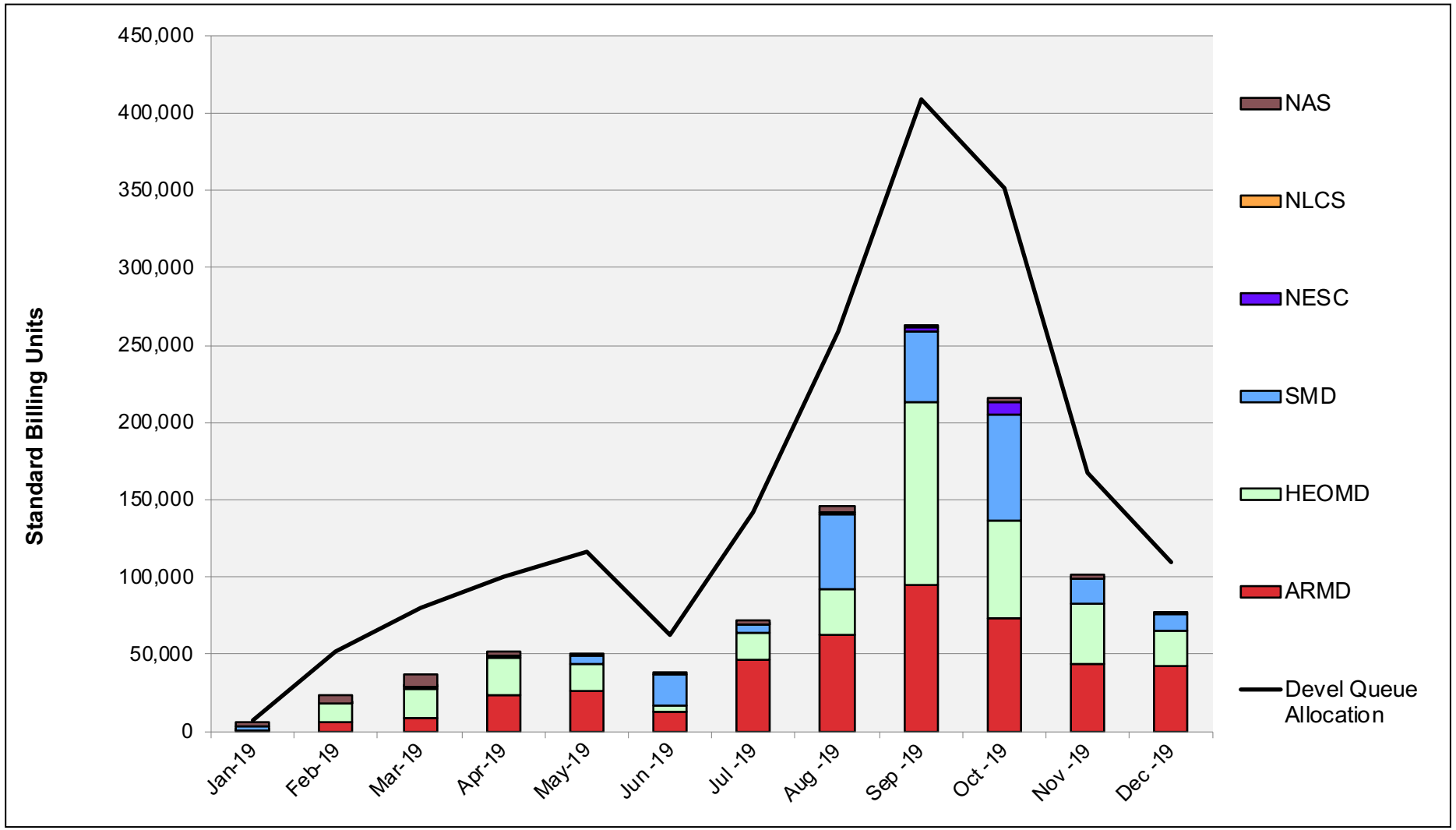
Aitken: Average Expansion Factor



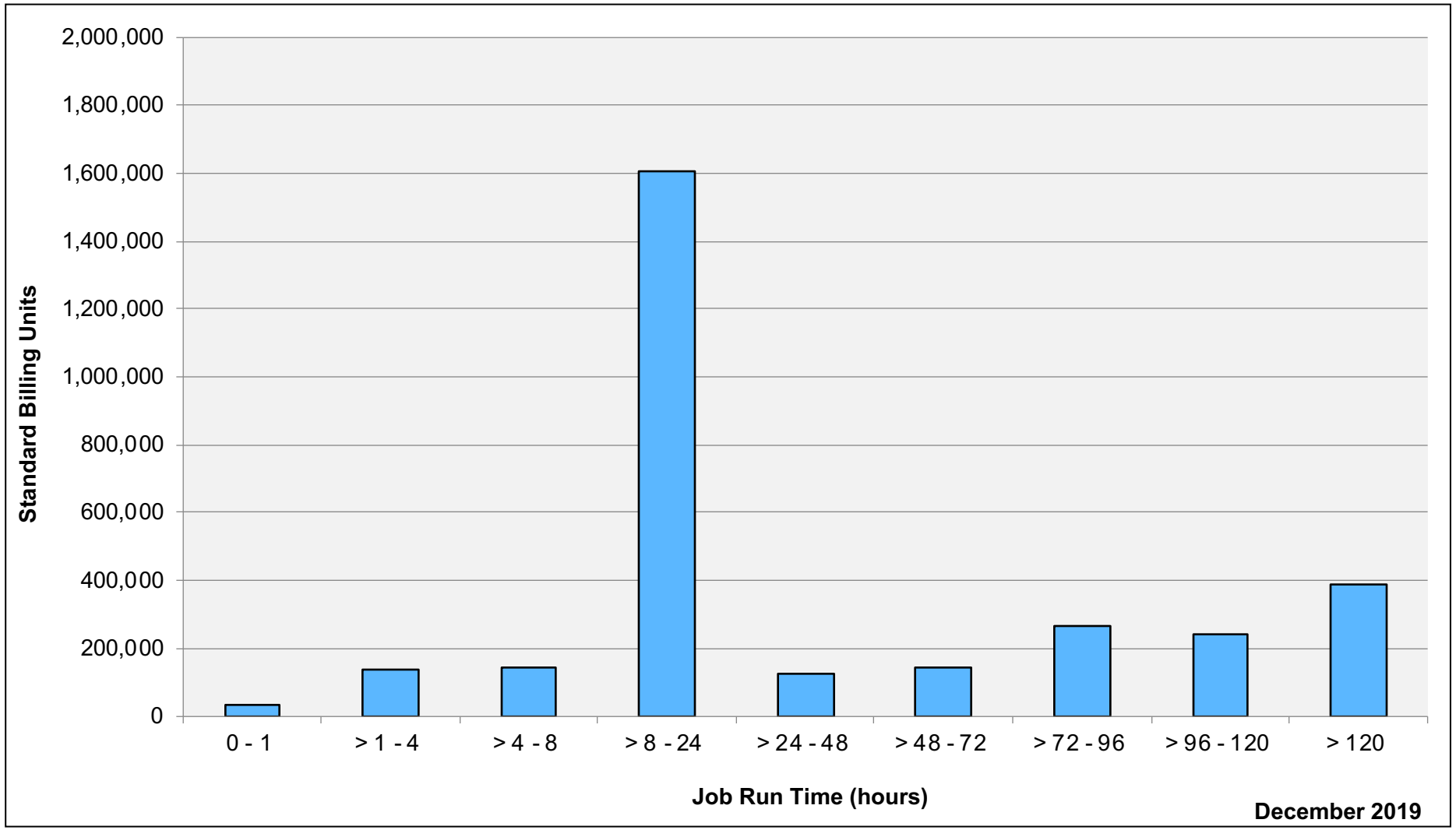
Electra: SBUs Reported, Normalized to 30-Day Month



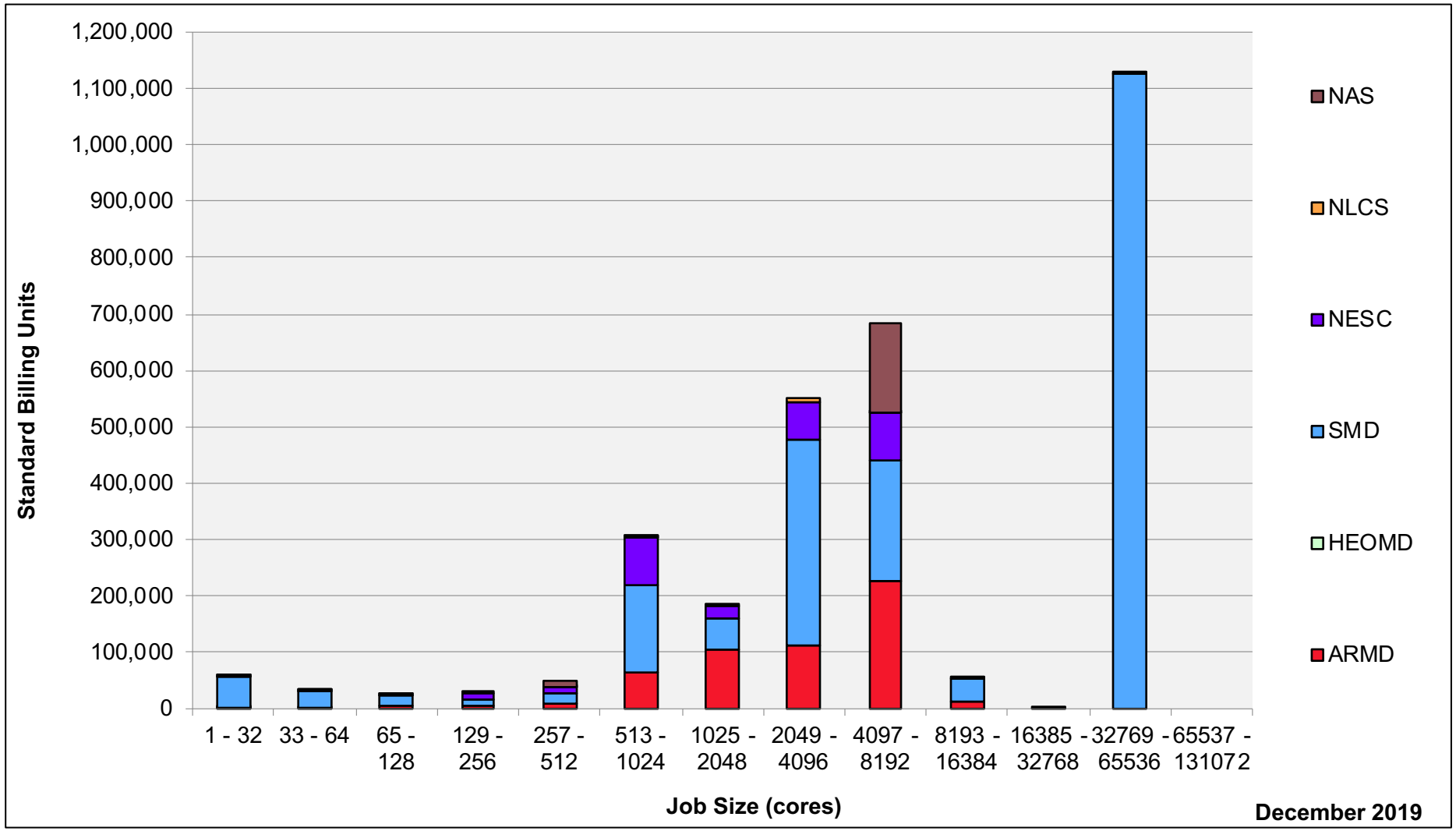
Electra: Devel Queue Utilization



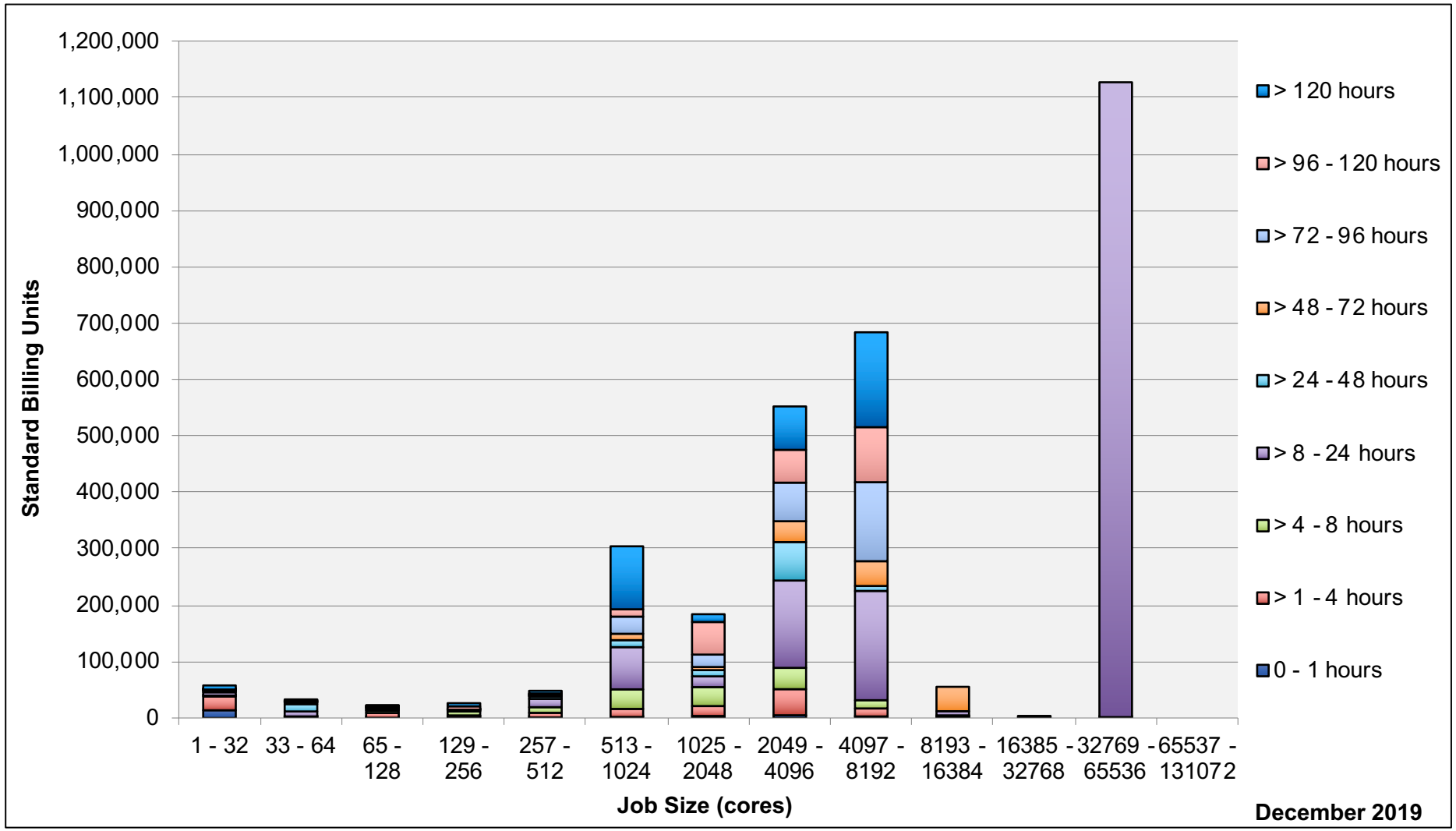
Electra: Monthly Utilization by Job Length



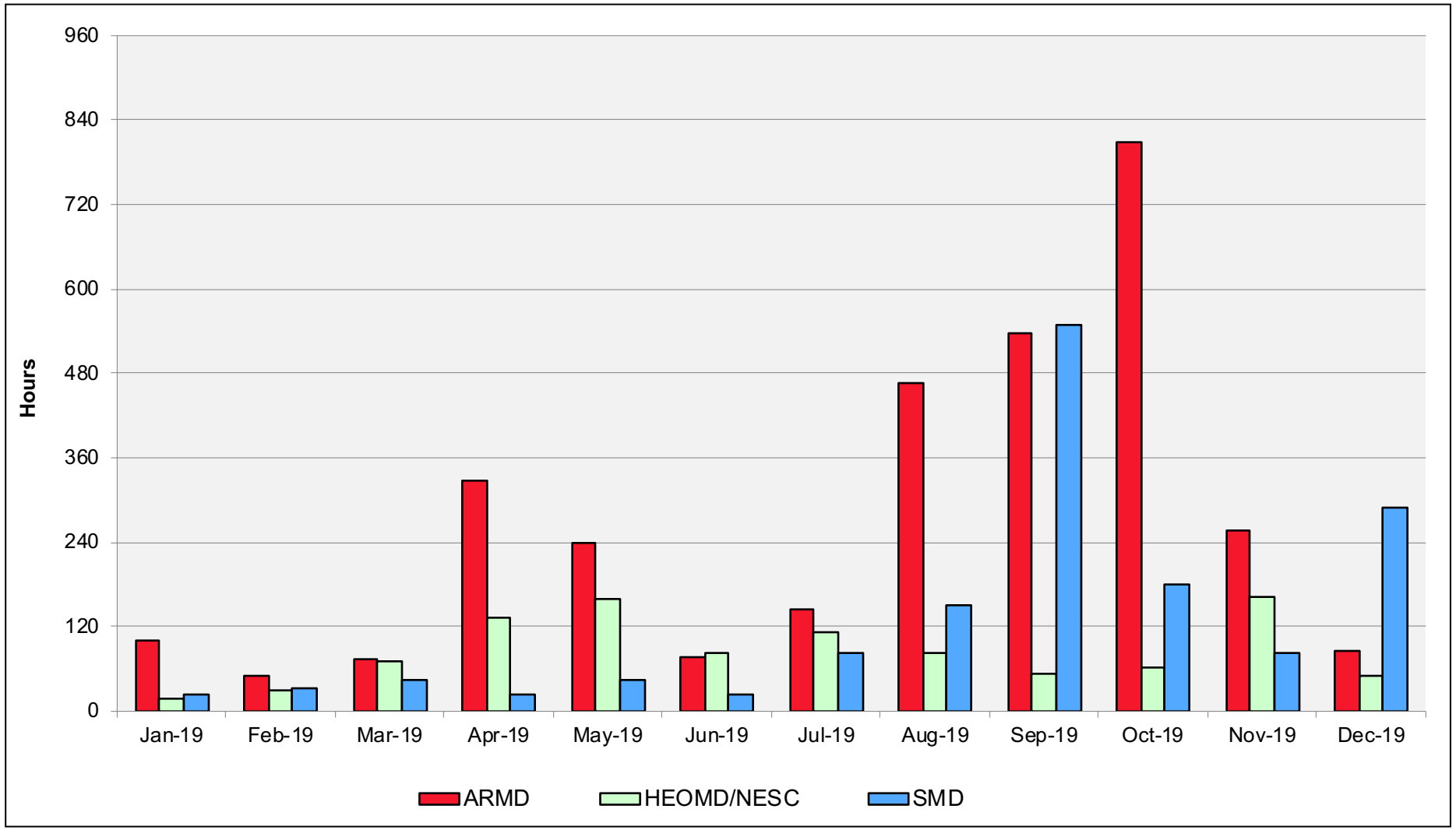
Electra: Monthly Utilization by Job Length



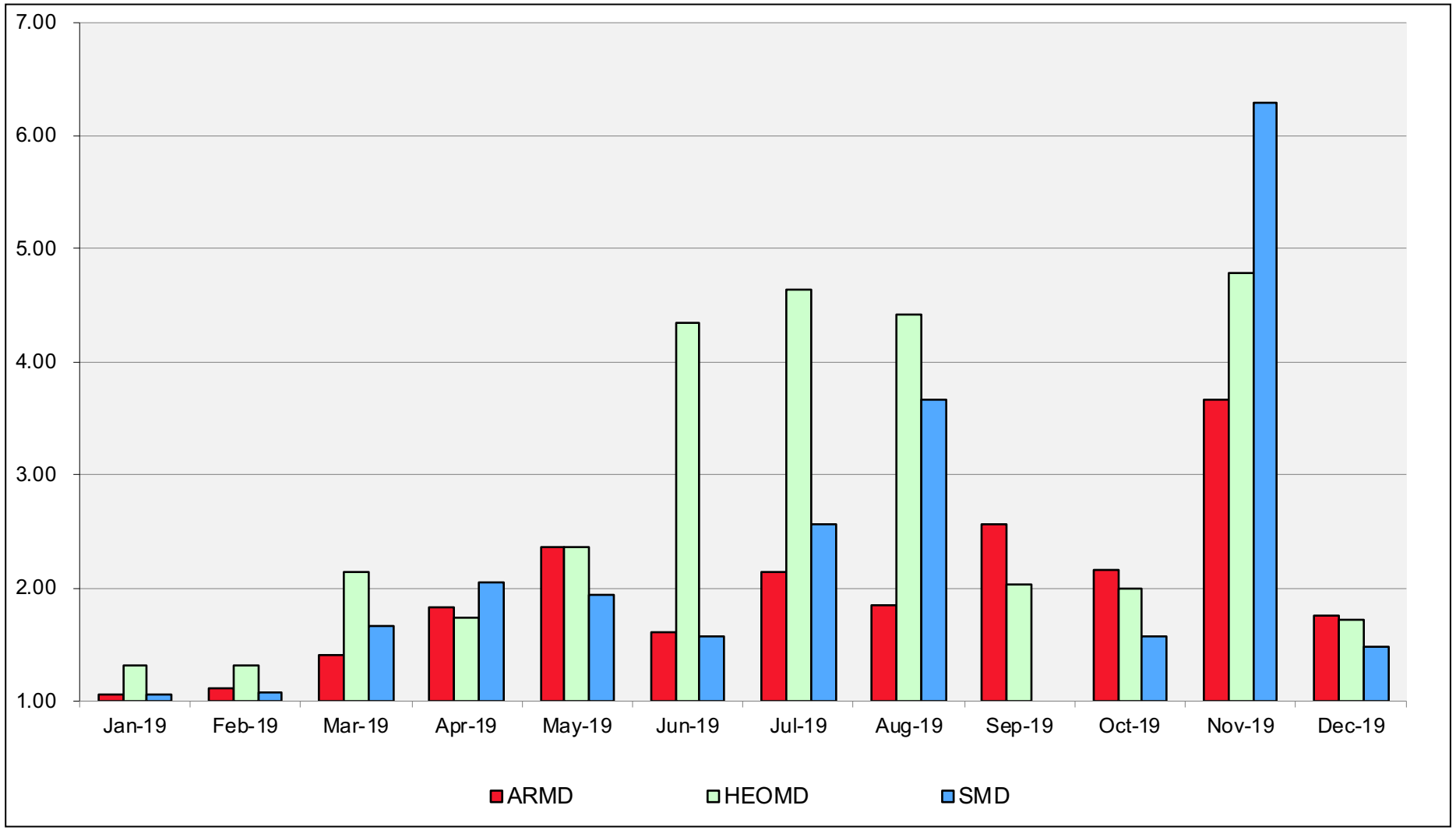
Electra: Monthly Utilization by Size and Length



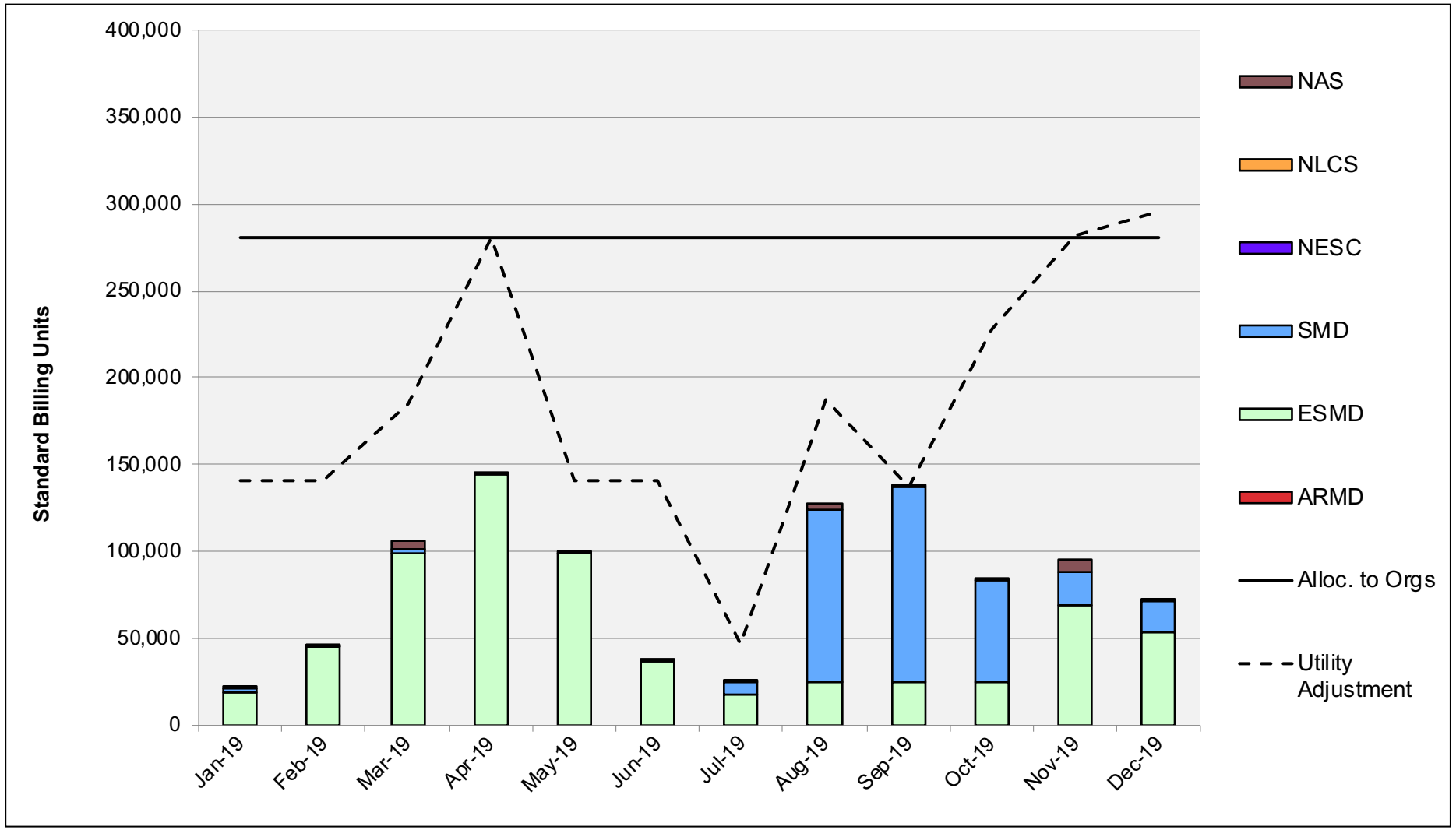
Electra: Average Time to Clear All Jobs



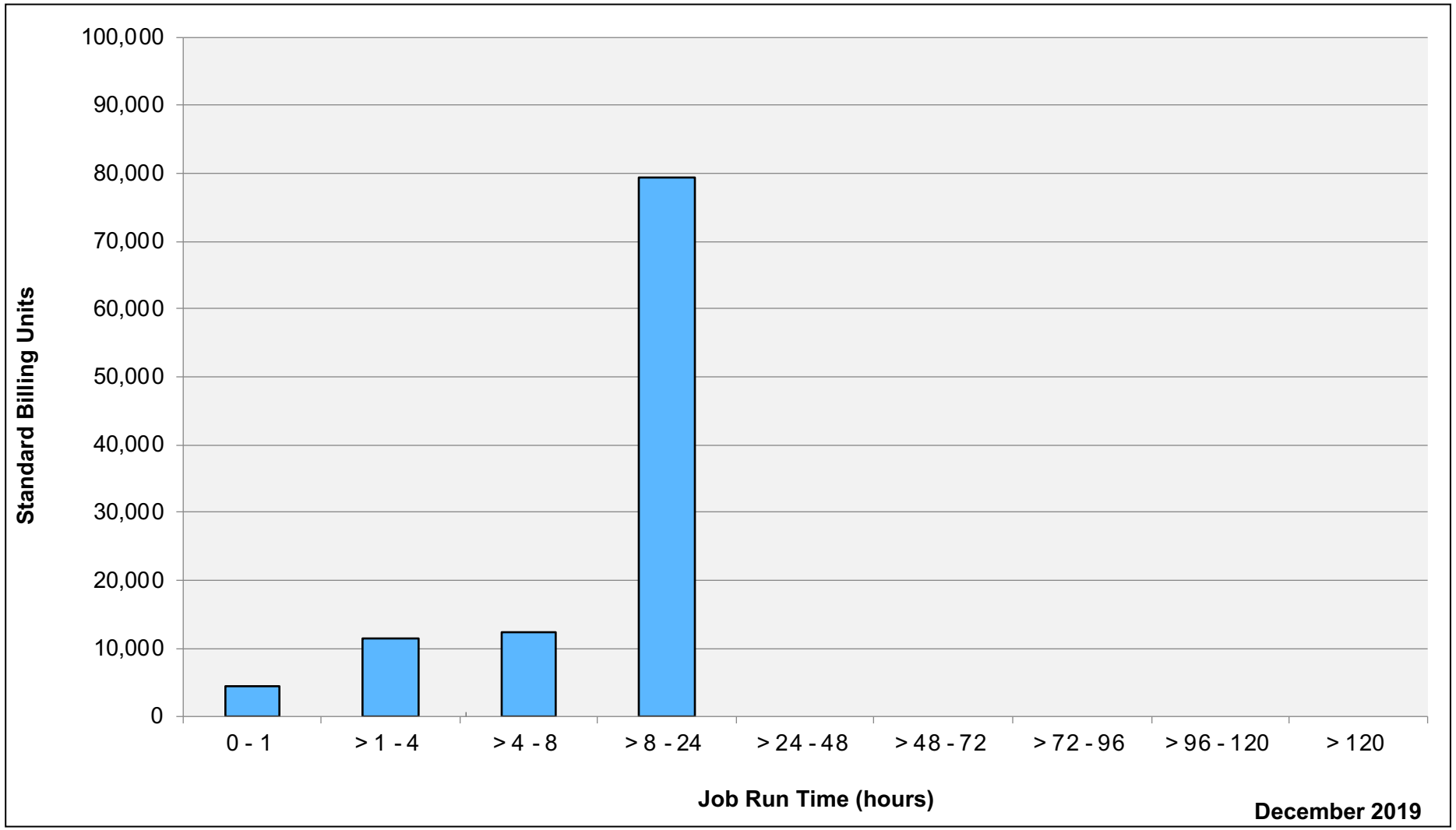
Electra: Average Expansion Factor



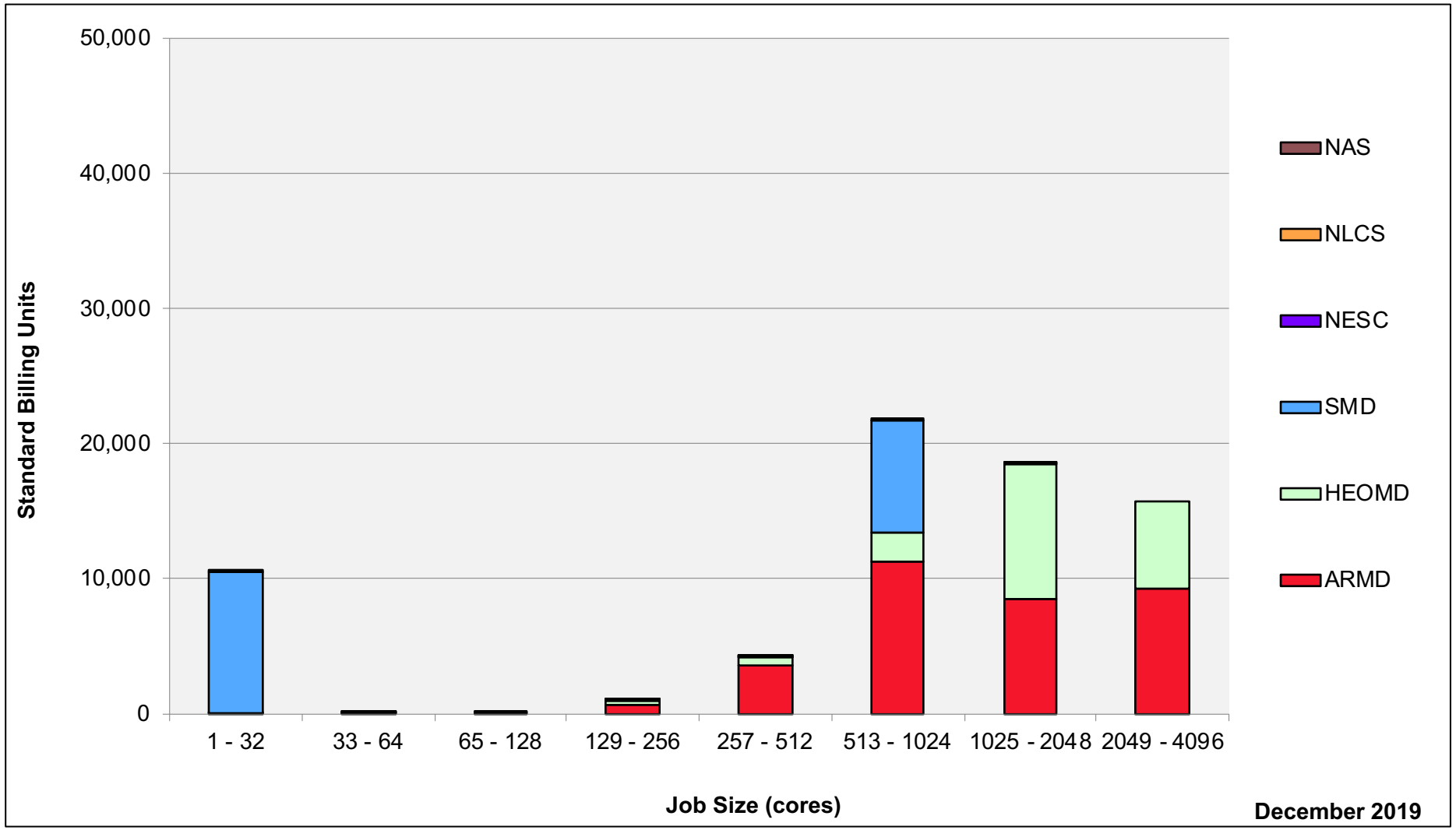
Merope: SBUs Reported, Normalized to 30-Day Month



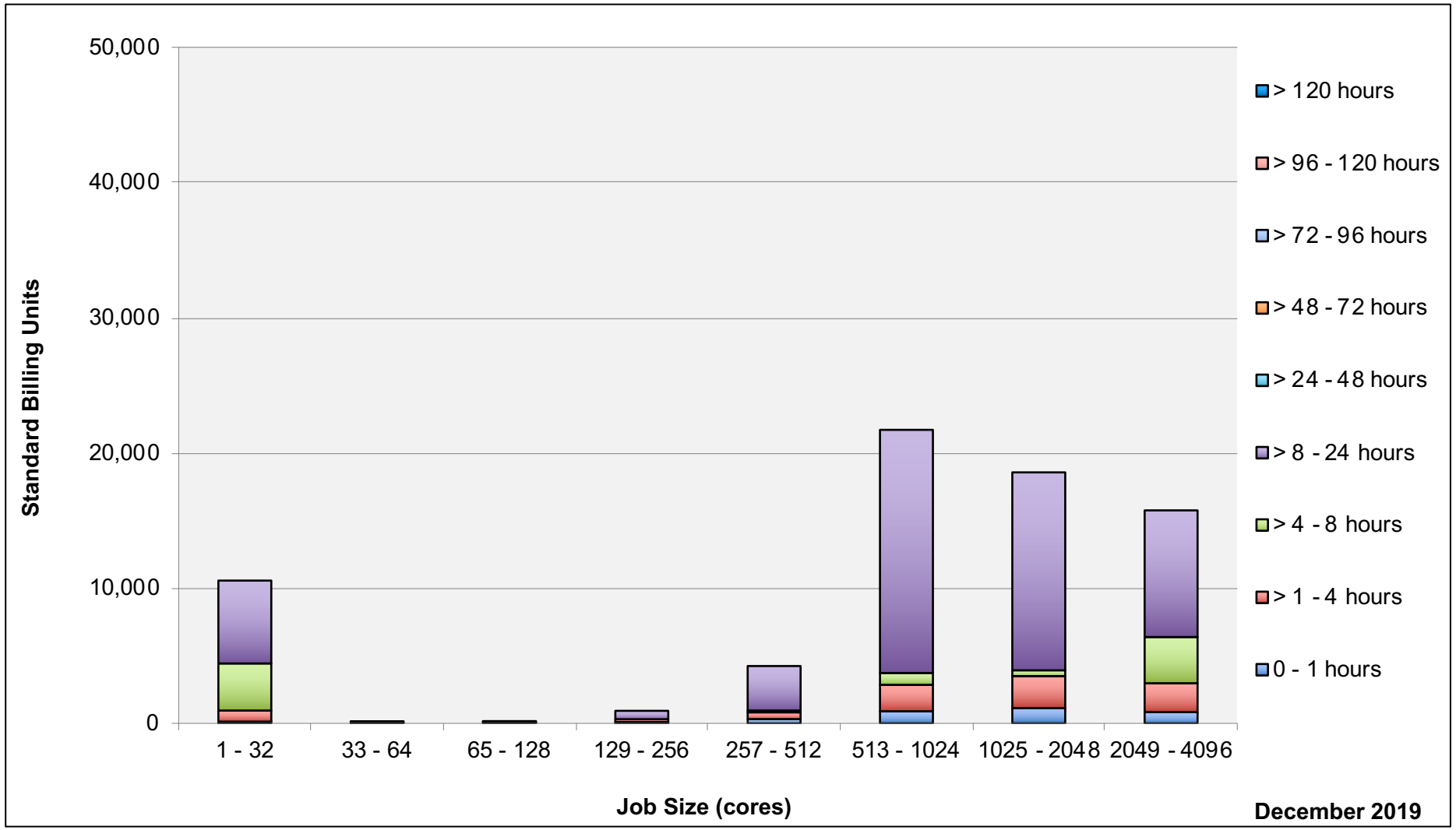
Merope: Monthly Utilization by Job Length



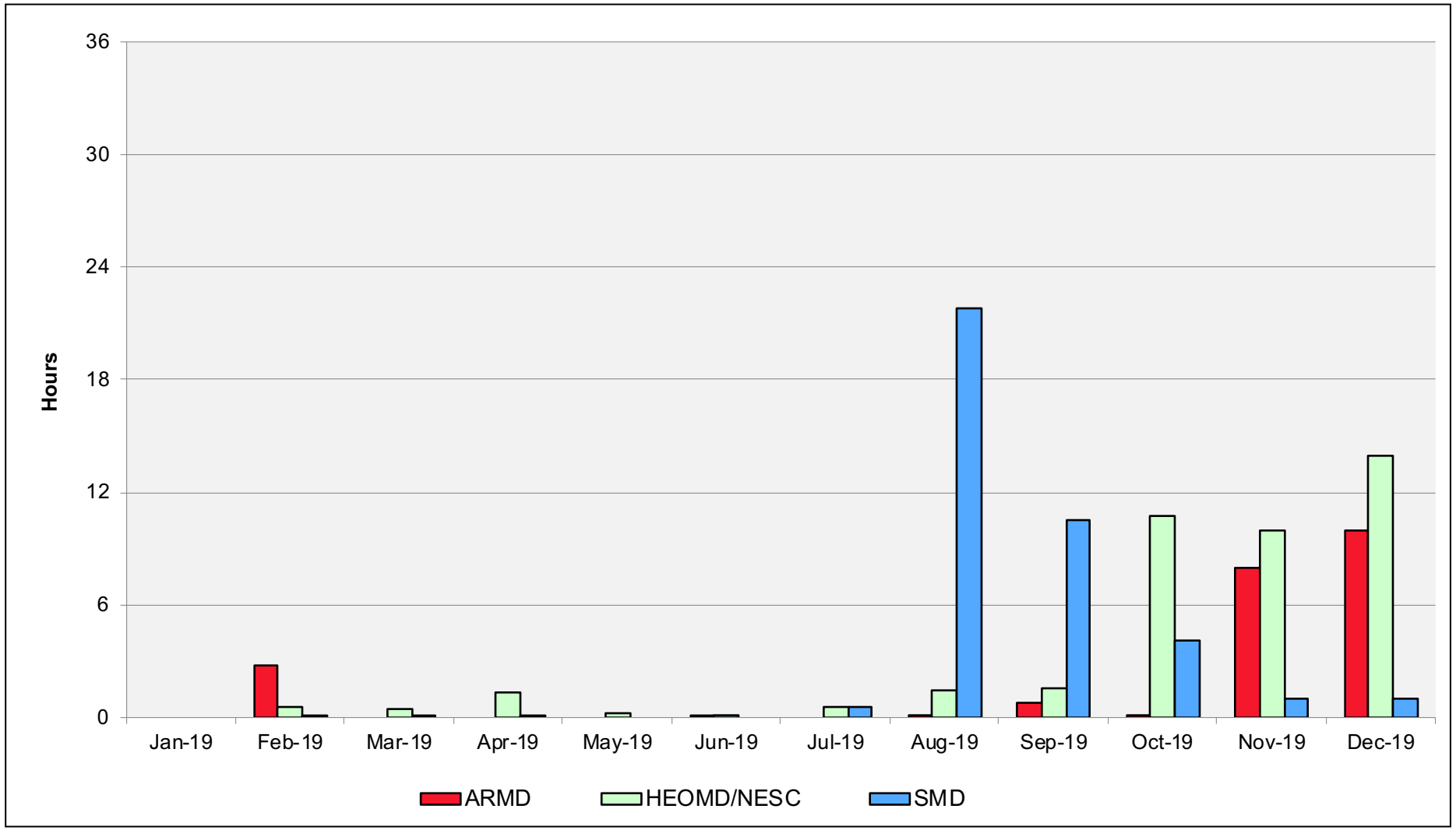
Merope: Monthly Utilization by Job Length



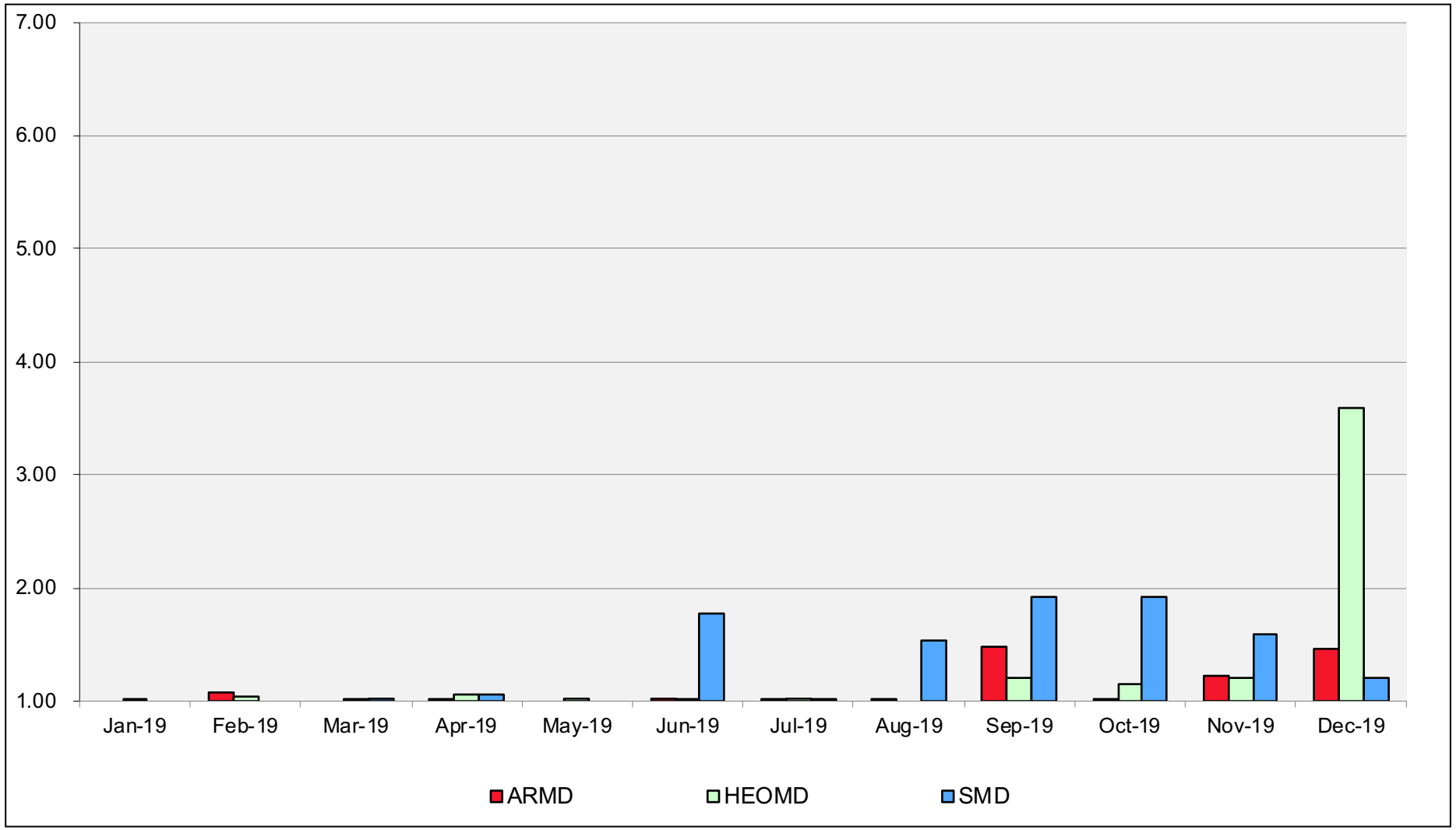
Merope: Monthly Utilization by Size and Length



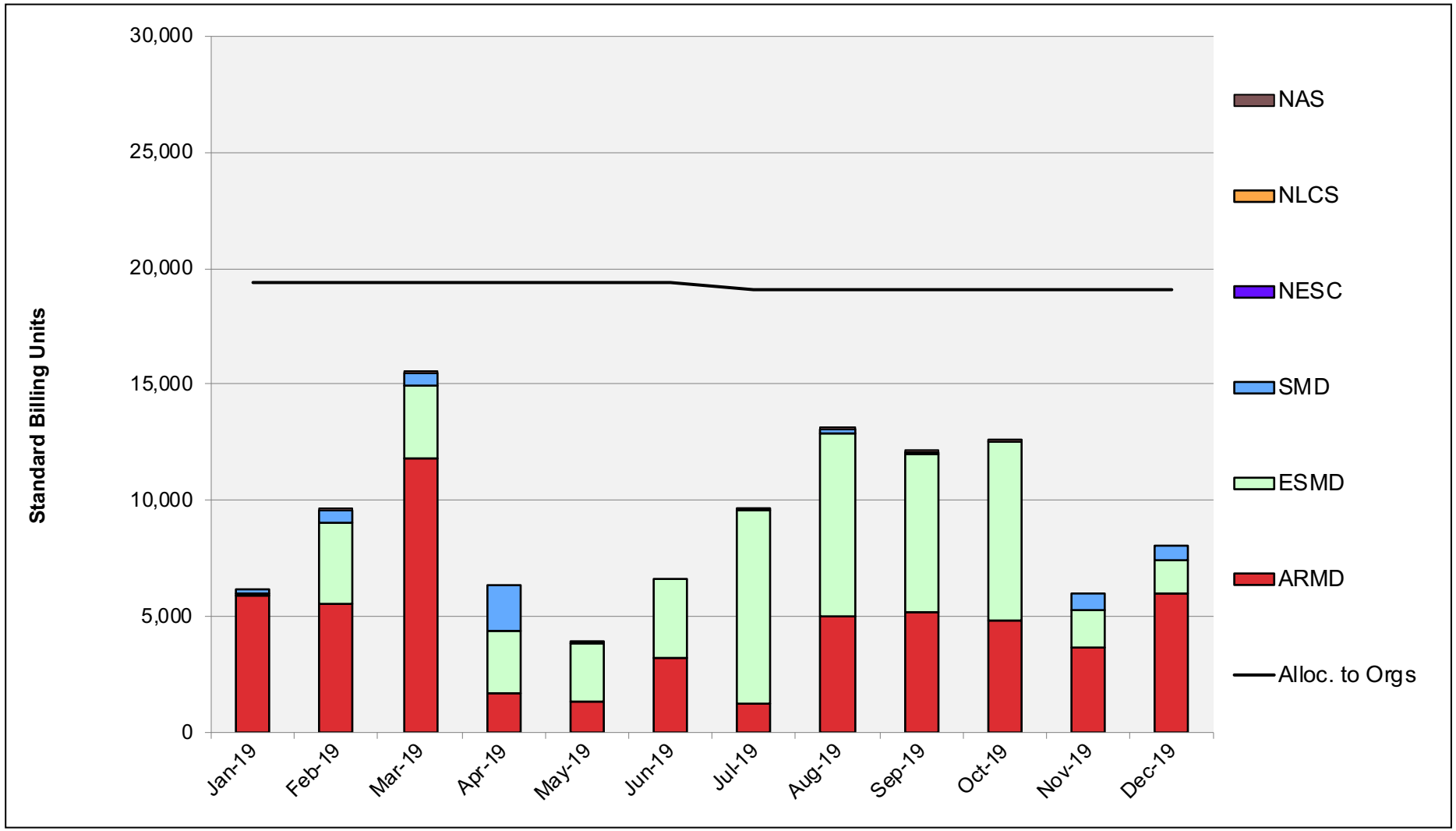
Merope: Average Time to Clear All Jobs



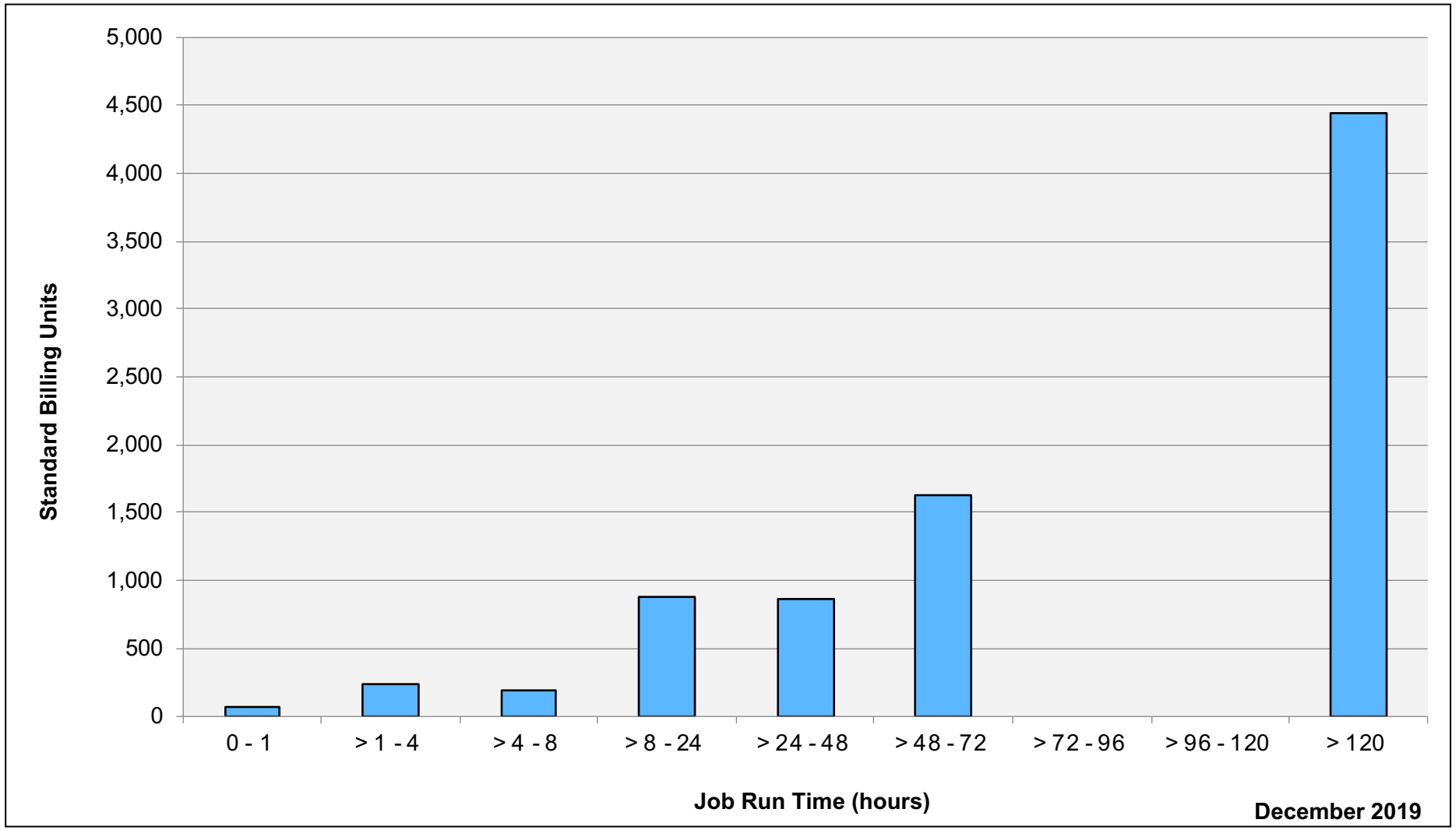
Merope: Average Expansion Factor



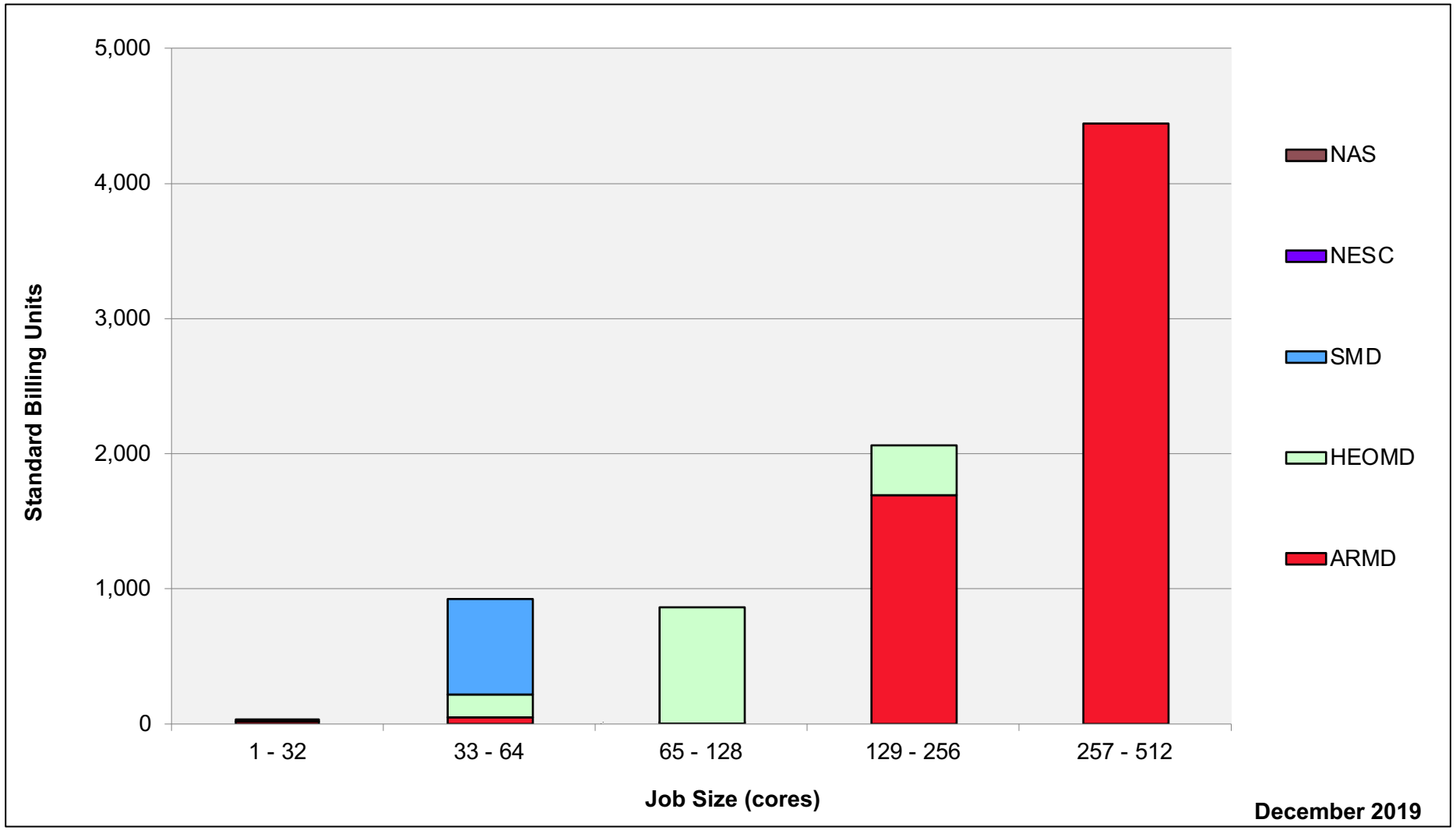
Endeavour: SBUs Reported, Normalized to 30-Day Month



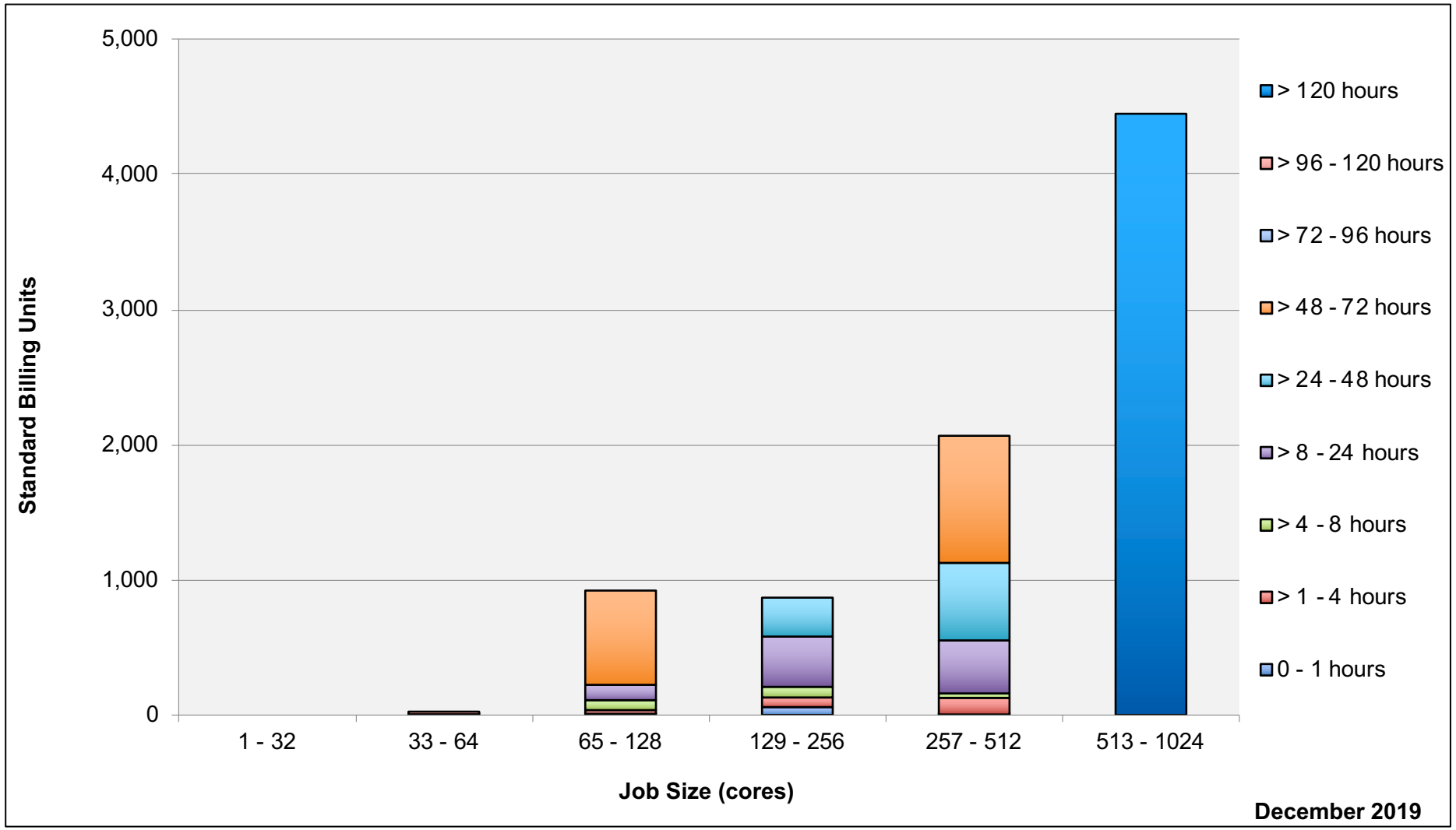
Endeavour: Monthly Utilization by Job Length



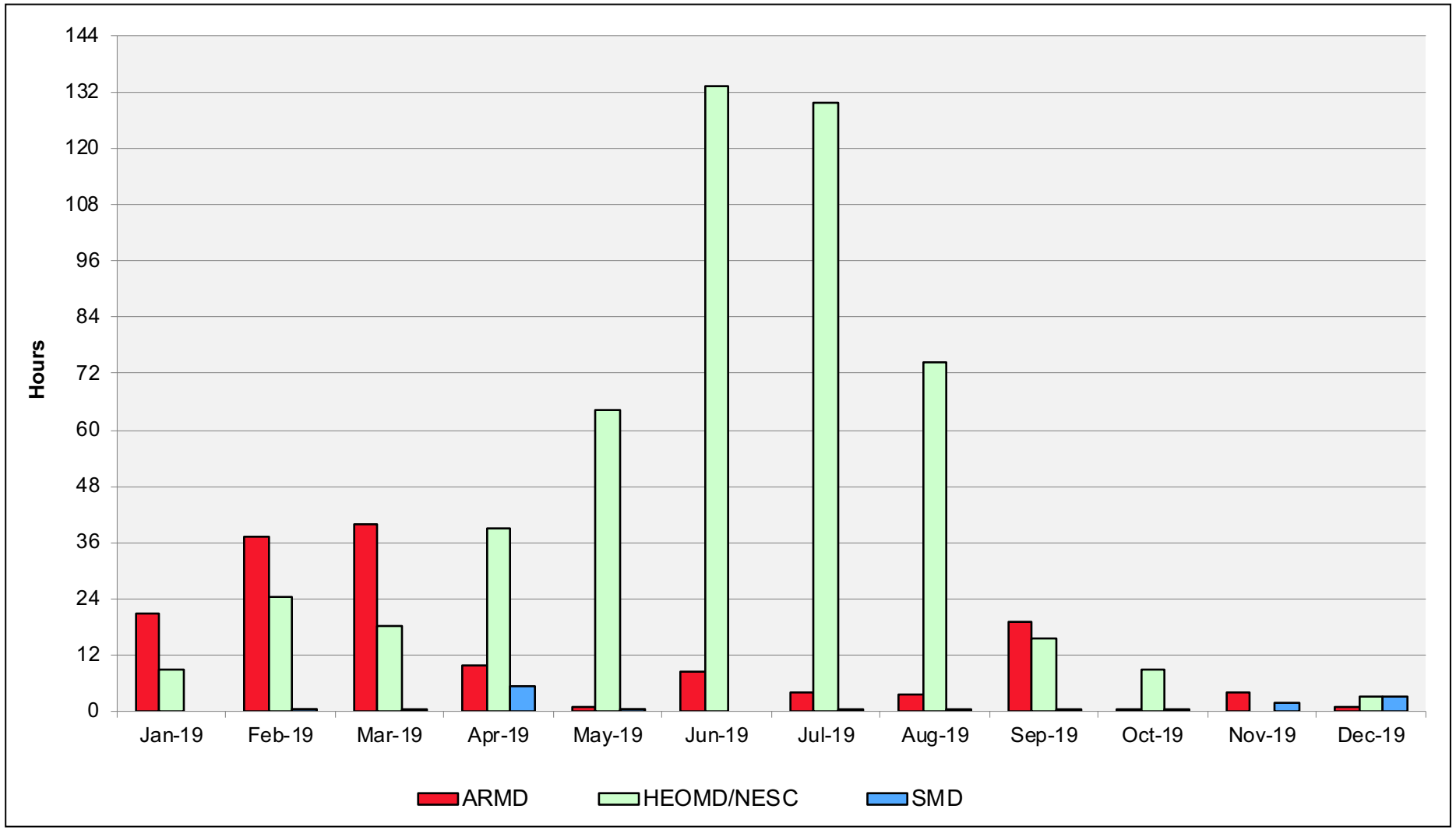
Endeavour: Monthly Utilization by Job Length



Endeavour: Monthly Utilization by Size and Length



Endeavour: Average Time to Clear All Jobs



Endeavour: Average Expansion Factor